TRANSACTIONS

OF

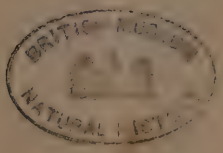
THE CLIFTON COLLEGE

Scientific Society

FOUNDED JUNE 25, 1869

PART I.

'VIRESQUE ACQUIRIT EUNDO'—Virg. *Æn.* IV. 175



Printed by
SPOTTISWOODE & CO., NEW-STREET SQUARE, LONDON
1871

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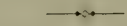
PREFACE.



This little volume needs, perhaps, a few words of preface, for it is the first one which the Clifton College Scientific Society has ever issued. The aim of a modest publication like ours differs greatly from that of the more elaborate and costly productions which the 'Learned Societies' send forth to the world, and we have perhaps been rash in assigning to such a trifle the high-sounding term 'Transactions.' But the word will do as well as any other for a title, though in using it we must not mislead our readers into the idea that our book is anything better than the record of a mere School Society. The *raison d'être* of the present volume is simply this: very many members of the College, and a large number of old Cliftonians and friends, have thought it would be desirable to issue in a collective form some interesting papers, read from time to time at the Scientific Society's Meetings, and to accompany these essays by a brief record of its pro-

ceedings. It was believed that the Clifton world generally would welcome such a book, and that it would possess in itself an interest which would justify its publication. And so our little venture is launched forth under these auspices. It is, we trust, but the pioneer of a long series of 'Transactions,' each volume superior in merit to the previous one, and all serving to show that the Clifton College Scientific Society has not been founded in vain. The beginning is, indeed, a humble one; but we hope for a successful career, as we are not unmindful of our motto,

'*Vires acquirit eundo.*'

M. J. B. W.
J. G.
J. F. M. H. S.
W. J. P. W.

INTRODUCTION.

The Clifton College Scientific Society was founded on June 25, 1869. At its first meeting only about eighteen members enrolled their names, and for some time afterwards the Society met but seldom, the audiences were scanty, and little general interest in its proceedings was excited throughout the school. Nor, indeed, does it seem to have been at first intended that the Society should be anything more than a union of a few boys, who had a common interest in scientific matters, and who wished occasionally to discuss such matters together. But the existence of such an association was essentially a precarious one, and after a few months it began to be felt that, to assure its permanence and general utility, it would be necessary to place the Society on a wider basis. The time seemed a good one for such a change, as the excellent and suggestive paper of Canon Kingsley had awakened a considerable amount of energy in the way of collecting for a Museum, and Natural History was then, for the first time, to be introduced into the regular teaching of the College. Besides, it had recently been proposed to found a Botanic Garden by subscription, and the Head Master had offered to give a 'local habitation' to a school museum in the handsome new Library which he had munificently promised to build. The Committee of the Society consequently determined to hold meetings at regular intervals, and, mainly by the praiseworthy efforts of several individual members, an interest was stirred up which had been hitherto unknown. The number of applicants for admission to membership rapidly increased, the Chemical lecture room was soon found

to be too small to contain the audiences that flocked to hear the proceedings, the papers read increased in merit, and at length it became necessary to limit the number of members to seventy, and that of occasional visitors to fifteen. Since this resolution was passed, in the spring of last year, the full complement of seventy has been always maintained, and it is even more gratifying to add that there are many names of candidates for admission on the Society's books.

The Meetings are held on alternate Fridays, at half-past six P.M., but there are occasionally extra meetings, when some private business requires to be discussed. The ordinary meetings take place in one of the College class rooms (each of which will not, on an average, seat more than seventy persons) ; but when there is to be a lecture of peculiar interest, it has been customary to meet in Big School, which affords ample accommodation for a large audience.

A new feature in the constitution of the Society deserves especial notice. In February of the present year (1871), it was proposed to found 'sections' for the study of certain sciences, and, as the plan met with a ready acceptance at the hands of the Society, seven of these sections have been formed, and are now in full working order. They are as follow:—Botany, Geology, Zoology, Entomology, Chemistry, Physics, and Archæology. A 'Director' of each section is nominated by the Society, and some one is appointed by him to keep the records, &c., with the title of 'Sectional Secretary.' Not more than ten members are admitted into each of these companies, and although it is not absolutely forbidden to join more than one section, it is at the same time discouraged, for the Committee believe that the best members of sections will be those who do not distribute their energy over many varied subjects. The President and Secretary of the Society are *ex officio* members of every section, and may attend the meetings when they please. In this way the sections are brought into close relation with the 'governing body' of the Society at large. It is left to the Director to summon the members together at such times as may suit general convenience, and indeed he is allowed to manage the section as may seem to him best, subject only to the control of the

General Committee. In most sections there are both evening meetings and excursions. Scientific journals are taken in and circulated, sectional libraries are being formed, and the geological adherents have already begun to make a collection of local fossils found by themselves. So far, the scheme works admirably, and it is hoped that when the next volume of 'Transactions' is issued a favourable report will be given from each one of the seven sections.

It will not be out of place here to mention what is being done with reference to the College Museum (to which allusion has already been made). A circular was issued not long ago explaining its aim and limits: this circular we shall here reprint, as it gives a good idea of the objects to be attained and the difficulties to be overcome in founding this highly desirable adjunct to the Scientific Society:—

CLIFTON COLLEGE MUSEUM.

For some time past a small collection of Natural History specimens has been in course of formation at Clifton College, intended as the nucleus of a School Museum. The want of a suitable apartment for their reception has, however, prevented any proper arrangement of these contributions being made, and they are almost wholly inaccessible to the pupils of the College, and may be said to be at present practically useless.

The Head Master has, however, recently built and presented to the College an extensive Library and Museum, so that a most favourable opportunity now exists for the full development of a long projected and highly desirable plan. A considerable sum of money will be required to fit up the Museum properly, to purchase certain specimens which are not likely to be procurable from private donors, and to form an Endowment Fund for its maintenance and management. Unfortunately, there are at present no funds available for the purpose, and aid must be sought from the generosity of relatives and friends of the pupils, for whose instruction and gratification the museum is about to be established.

It may, perhaps, be well to state here the objects and limits of the proposed Museum, and the method to be adopted in its arrangement. A School Museum, to be a thoroughly useful one, should be typical and complete; yet, unless some definite plan be formed at the very onset to procure what is really wanted, *and nothing else*, there is great danger of a collection of sundry miscellaneous objects being formed, interesting enough, perhaps, in themselves, but valueless for all scientific or educational purposes. The experience of other such institutions has shown that, unless a free right of accepting or declining donations of specimens be granted to the

Curators, it is impossible to make a good museum. Moreover, the amount of space for the disposal of the collection will necessarily be somewhat limited, and it must be turned to the best account. For these and other reasons it has been decided, with the approval of the Head Master, that the Museum shall be essentially a British one, and shall illustrate the Natural History and Antiquities of our land by good specimens, systematically arranged, under the departments of Zoology, Botany, Geology, Mineralogy, and Archæology. In addition to this there will be a collection of rare and curious objects, derived from all sources, which may be considered useful for the purposes of scientific teaching, and a large typical series to be used at the lectures and demonstrations given in the College on Comparative Anatomy, and other branches of Natural History.

The Committee of Management will only accept of such specimens as can be classed under some one of these heads. All the various collections will be available, under proper regulations, for the use of the boys, and every assistance will be given to those whose inclinations and tastes lead them to the special study of any particular branch of Physical Science. Mr. Barrington-Ward, Natural History Master in the College, has been appointed Curator of the Museum, and the charge of its several sections will be placed in the hands of Sub-curators, selected, for the most part, from members of the College Scientific Society who may have given special attention to the study of particular branches of science. The general administration of the Museum and its funds will be vested in a Committee of Management, to consist of the Curator, Sub-curators, and some other persons nominated by the Head Master.

A Museum founded with these objects, and energetically conducted, can hardly fail to be of real service in a large public school, and, apart from the interest it will give to all the boys, it will do much to foster habits of observation, and encourage many to give their attention to some of the most delightful branches of study.

The Committee earnestly request assistance in their undertaking, and more especially solicit donations and annual subscriptions in money. As already mentioned, the expense of fitting up suitable cases and drawers will be very considerable, while many purchases must be made from time to time so as to render the Museum complete, and it will most likely soon be necessary to procure some paid assistance in preparing and duly preserving the specimens. The Head Master will allow any small sum which parents or guardians may wish their boys to contribute to be entered terminally in the school accounts.

Contributions of objects of interest in any of the departments of the Museum will also be gladly received. Communications respecting these should be addressed to M. J. Barrington-Ward, Esq., Clifton College, who will give every information to intending donors. Named specimens of *British* Fossils, Minerals, Stuffed Animals, Shells, Crustacea, Insects, Dried Plants, Coins, and Antiquities; all Skeletons and Bones of Vertebrata, and good Animal preparations in spirit, &c., will be highly acceptable. Any Collector or

Curator of a Museum who can spare some duplicate specimens will greatly oblige the Committee and materially help them in their efforts. Gifts of live plants are also solicited for the Botanic Garden, which is now in course of formation, and which will (when completed) be under the charge of the Museum Committee.

In response to this appeal a considerable sum has been contributed, and a contract for the erection of a large portion of the drawers and cases is now almost completed. As a considerable number of useful specimens has been meanwhile accumulating, in a very short time the Museum will have begun to exercise all the good which is expected from it. The Botanic Garden (to which reference has been made in the circular) is now laid out, and contributions of plants for it have been most kindly given by the Directors of the Royal Botanic Gardens at Edinburgh, Regent's Park, and Glasnevin, by the Board of Trinity College, Dublin, and by the Professor of Botany at Oxford, and several private contributors. There are still, however, many specimens required for this Garden, and both it and the Museum stand greatly in need of contributions in money. The Herbarium is already in very fair progress, and is likely soon to be a good one, so far as British plants are concerned. A large and excellent collection of plants, gathered by the late Miss Mills, and presented by her nephew, forms the nucleus of a rapidly increasing series of British specimens. A complete list of subscribers to the 'Museum and Garden Fund' is appended to the present volume of 'Transactions.'

In conclusion, it may be said that there seems to be a brilliant sphere of usefulness in store for the Clifton College Scientific Society. Not many schools in England possess such advantages for the study of science, within and without. We have no fewer than five natural science masters, all of them ready and willing to help in every scientific pursuit, and some of whom bestow no small share of attention upon the actual working of this Society. The Museum and Garden will be of the highest value and interest to us all, and the Head Master encourages the Society in every possible way. The neighbourhood is an exceedingly interesting one, both in its flora, geological structure, and antiquities. There is

ample scope for every member to obtain knowledge and delight in the many paths of science, and it will be indeed strange if, in improving ourselves, we do not contribute our little mite to the vast store of knowledge which the patient labour of many ages has been gradually accumulating. The opportunity is ours; it will be our own fault if we fail to use it. Let us think of the memorable words of John Ray:—'Naturæ divitiæ plane sunt inexhaustæ, nec cuiquam post mille secula nato deerit quod scrutetur, et in quo se cum laude exerceat.'

LIST OF MEMBERS.

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M. J. BARRINGTON-WARD, B.A., F.L.S., &c.

SECRETARY.

J. F. M. H. STONE.

TREASURER.

REV. J. GREENE, M.A., M.E.S.L., &c.

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R. W. WILSON.
R. F. BRUNSKILL.

HONORARY MEMBERS.

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M. J. B. Ward, B.A., F.L.S., &c.
Rev. J. Greene, M.A., M.E.S.L., &c.
Rev. H. J. Wiseman, M.A.
Rev. H. C. Watson, M.A., F.R.A.S.
C. J. Peile, B.A.
G. F. Rodwell, F.R.A.S., &c.
Rev. B. Hartnell, M.A.
G. T. Atkinson, B.A., F.C.S.
Rev. Canon Moseley, M.A.
T. Proctor, Esq.
J. Saunders, Esq.
F. F. Tuckett, Esq., F.R.G.S.
F. Black, Esq., M.D.
J. G. Grenfell, B.A.
J. Perry, B.E.
Rev. H. N. Ellacombe, M.A.

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E. O. Ashby, Oxford
W. F. Howlett, Oxford
F. W. Shaw
A. W. Brodie, Cambridge
W. Mogg, Cambridge

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Allen, J.
Anderson, W. H. W.
Aspland, W. S.
Baillie, W.
Batchelor, A. E.
Berrington, A.
Blanshard, C. T.
Brown, H. R. F.
Brownlow, C. B.
Brownlow, W.
Brunskill, R. F.
Bush, J. P.
Bush, R. E.
Claxton, W.
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Duncuft, J.
Evill, W. E.

Ffooks, L. B.
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Smyth, W. S.
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Vickers, H. O.
Walsh, D. T.
Ward, M. J.
Warren, A.
Warren, E. P.
Wedderburn, F. E. K.
Wills, H.
Wilson, A. C.
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DIRECTORS OF SECTIONS.

Botany—M. J. B. Ward, B.A.
Geology—J. G. Grenfell, B.A.
Entomology—Rev. J. Greene, M.A.
Archæology—R. W. Wilson
Zoology—J. F. M. H. Stone
Chemistry—W. A. Smith
Physics—W. J. P. Wood

RULES.

I.—That this Society be called the 'CLIFTON COLLEGE SCIENTIFIC SOCIETY.'

Constitution.

II.—That the Society consist of Ordinary, Corresponding, and Honorary Members.

Officers.

III.—That the Officers of the Society consist of a President, Secretary, Treasurer, and three Members of Committee, to be elected from and by Members of the Society, with the exception of the Secretary, who shall be chosen by the Committee from their own number. All officers, excepting the President, to be elected terminally.

Management.

IV.—That the affairs of the Society shall be conducted by the above Officers.

Secretary.

V.—That the duties of the Secretary be, to keep a list of all the Members of the Society, and of all former Members and Benefactors, who may wish to receive the Transactions of the Society; to give notice of meetings, and to keep a detailed report of the proceedings, as well as lists of members and visitors present at each meeting. In the absence of the Secretary, the President may appoint any Member of the Committee to take minutes of the proceedings.

Treasurer.

VI.—That the duties of the Treasurer be, to collect all sums of money due to the Society, to receive all donations of money, and to disburse all sums of money payable by the Society out of the funds entrusted to him.

That the Treasurer furnish half-yearly a detailed account of the receipts and disbursements, to be audited by the Committee.

Members.

VII.—That the number of Members be seventy, of whom ten shall be elected from the Junior School.

That Ordinary and Corresponding Members shall be proposed and seconded at a meeting of the Society, and elected at the meeting next following. Less than three-fourths of the votes of the Members present to exclude any candidate.

That Honorary Members shall be elected by the Committee.

That a subscription be payable terminally, (the amount to be fixed by the Committee,) but in no case to exceed 2*s.* 6*d.* for the Upper and 2*s.* for the Junior School.

That all subscriptions must be paid between the first and second meetings of the term, and that any member retiring from the Society be required to pay all subscriptions due.

That, under penalty of expulsion from the Society, all Members be required to attend two-thirds of the Ordinary Meetings in each Term, except for reasons deemed sufficient by the President. Attendance at Extraordinary Meetings to be optional.

That a certain number of tickets for admission to Ordinary Meetings shall be issued by the President for collegians who are not Members of the Society, but that, on application being made to him, any Member may introduce other visitors.

Sections.

VIII. That Sections be formed for the more accurate study of the different branches of Science, and that the Directors of these Sections be chosen by the Society.

That the Sections shall hold meetings as often as may seem fit to their respective Directors, at which any Members of the College, with the sanction of the Director, may attend.

Meetings.

IX. That Ordinary Meetings of the Society be held once a fortnight, but that the President be empowered to call Extraordinary Meetings at his discretion.

New Rules.

X. That any Member of the Society have power to propose any new rule, or any alteration in an old one, provided the motion be seconded by another Member, and that notice of at least one week be given to the Secretary.

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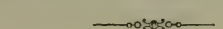

At the Introductory Meeting of the Society, the following Inaugural Address was delivered by the Rev. Canon Kingsley, Rector of Eversley, and Chaplain in Ordinary to Her Majesty :—

I shall tell you to-day what I think you may do for a museum, and how you may improve yourselves by doing it without interfering with your regular work. Of course that must never be interfered with; you are sent here to work. All of you here, I suppose, depend for your success in life on your own exertions. None of you are born (luckily for you) with a silver spoon in your mouth, to eat at other people's expense and live in luxury and idleness. Work you must, and I don't doubt that work you will, and let nothing interfere with your work; but I do not think that helping the museum need do that, and I will tell you why.

The first thing for a boy to learn after obedience and morality is a habit of observation,—a habit of using his eyes; it matters little what you use them on, provided you do use them.

They say knowledge is power—and so it is—but only the knowledge you get by observation. Many a man is very learned in books, and has read for years and years, and yet he is useless. When you set him to do work he makes a mess of it. He knows *about* all sorts of things, but he can't *do* them. He is what is called a pedant, because he has not used his eyes and ears. He has lived in books. He knows nothing of the world about him, or of men and their ways,

and therefore he is left behind in the race of life by many a shrewd fellow who is not half as book-learned as he, but who *is* a shrewd fellow—who keeps his eyes open—who is always picking up new facts and turning them to some practical use.

Now, I don't mean to undervalue book-learning—no man less. All ought to have some of it, and the time you spend here on it is not a whit too long; but the great use of a public-school education to you is, not so much to teach you things as to teach you how to learn—to give you the noble art of learning, which you can use for yourselves in after life on any matter to which you choose to turn your mind. And what does the art of learning consist in? First and foremost, in the art of observing. That is, that the boy who uses his eyes best on his book observes the words and letters of his lesson most accurately and carefully—that is the boy who learns his lessons best, I presume.

You know as well as I know, one fellow will sit staring at his book for an hour without knowing a word about it, while another will learn the thing in a quarter of an hour. Why? Because one has actually not *seen* the words; he has been thinking of something else, looking out of the window, repeating the words to himself like a parrot. The other fellow has simply, as we say, looked sharp; he has looked at the lesson with his whole mind, seen it, and seen into it, and therefore knows all about it.

Therefore, I say, that everything which helps a boy's power of observation helps his powers of learning; and I know from experience, that nothing helps that so much as the study of the world about you, and especially of natural history,—to be accustomed to watch for curious objects, to know in a moment when you have come upon anything new—which is observation; to be quick at seeing when things are like and when unlike—which is classification,—all that must, and, I well know, does, help to make a boy shrewd, earnest, accurate, ready for whatsoever may happen. When we were little boys, a long while ago, we used to have an old book, called 'Evenings at Home,' in which was a story called 'Eyes and No Eyes,' and that story was of more use to me than any dozen other stories I ever read.

A regular old-fashioned formal story it is, but a right good one, and thus it begins:—

'Well, Robert, where have you been walking this afternoon?' said Mr. Andrews, to one of his pupils at the close of a holiday.

Oh! Robert had been to Brownheath and round to Campmount, and home through the meadows.

But it was very dull; he hardly saw a single person; he had rather by half have gone by the turnpike road.

'But where is William?'

Oh! William started with him, but was so tedious—always stopping to look at this thing and that—that he preferred walking alone, and so went on.

Presently, in comes Master William, dressed, no doubt, as we wretched boys used to be dressed forty years ago, in his frill collar and skeleton monkey jacket, and light trousers buttoned over it, and not coming down to his ancles, and a pair of low shoes that always came off in heavy ground—and terribly dirty and wet he is; but he never had such a pleasant walk in his life, and has brought home a handkerchief full of curiosities.

He has got a piece of mistletoe, and wants to know what it is; and seen a woodpecker and wheatear, and got strange flowers off the heath; and hunted a peewit, because he thought its wing was broken, till of course it led him into a bog, and wet he got; but he did not mind, for in the bog he fell in with an old man cutting turf, who told him all about turf-cutting, and gave him an adder; and then he went up a hill, and saw a grand prospect, and wanted to go again and make out the geography of the county by Carey's old county map—which was our only map in those days; and because the place was called Campmount, he looked for a Roman camp, and found one; and then he went to the river, and saw twenty things more, and so on, and so on, till he brought home curiosities enough, and thoughts enough to last him a week.

Whereon Mr. Andrews, who seems a sensible old gentleman enough, tells him all about his curiosities, and then it turns out that Master William has been over exactly the same ground as Master Robert, who saw nothing at all.

Whereon, says Mr. Andrews, truly enough, in his solemn old-fashioned way, 'So it is, one man walks through the world with his eyes open, another with them shut, and upon this difference depends all the superiority of knowledge which one man acquires over another. I have known sailors who had been in all quarters of the world, and could tell you nothing but the signs of the tippling houses, and the price and quality of the liquor. On the other hand, Franklin could not cross the channel without making observations useful to mankind. While many a vacant and thoughtless

man is whirled through Europe without gaining a single idea worth crossing the street for, the observing eye and inquiring mind find matter of improvement and delight in every ramble. Do you, then, William, continue to make use of your eyes; and you, Robert, learn that eyes were given you to use.'

And when I read that story as a very little boy, I said to myself, 'I *will* be Mr. Eyes, I will not be Mr. *No* Eyes;' and Mr. Eyes I have tried to be ever since; and Mr. Eyes, I advise you—everyone of you—to be, if you wish to be happy and successful.

I am happy to say that there are many of you who are already working well at chemistry; some who have already begun to use their eyes and to make collections of plants, insects, birds' eggs—that is good as far as it goes: as for birds'-nesting, I think it a manly and excellent pursuit, and should like to go birds'-nesting myself now.

But see, because every boy collects for himself, there is a great deal of useless destruction of eggs, especially of the small soft-billed birds, which are easiest got—these are the very ones that ought to be spared, on account of their great usefulness to the farmer in destroying insects; and next, pray where will nine-tenths of their eggs be some seven years hence? Smashed and in the dust-hole, and so with the insects and plants. Now, it seems to me that if fellows were collecting for a college museum, instead of each one for himself, it would save a great deal of waste, and save the things themselves likewise.

As for a fellow liking to say, 'I have got this and I will keep it to myself; I like to have a better collection than anyone else,' that is natural enough, but, like a great many natural things, rather a low feeling. Which is better, to keep a thing to yourselves locked up in your own drawer, or to put them in the common stock for the pleasure of everyone? And which is really more honour to you, to be able to say to two or three of your friends, 'I have got an egg which you have not,' or to have the egg, or whatever else it may be, in a public collection, to be seen by everyone—by boys years hence when you are grown up? For myself I can't think of a better way of keeping up a corporate feeling in the College, and binding the different generations as they succeed each other, than a museum of this kind, in which boys should see the names of those who have gone before them, as having presented this or that curious object.

There are so many of you who have relations abroad or in

the country, that you will be able to obtain from them rare and curious objects that you could not collect yourselves; and I advise you to turn sturdy beggars, and get a hold (by all fair means) of anything and everything worth putting into the museum, anything which you can coax or bully out of anybody whatsoever, old or young.

I should wish you to begin to collect in the next vacation. What can you do better? I am sure your holidays would be much happier for it. I don't think boys' holidays in general are so very happy. *Mine* used to be; but why? Because the moment I got home I went on with the same work in which I employed every half-holiday—natural history and geology. But many boys seem to me in the holidays very much like Jack when he is paid off at Portsmouth. He is suddenly freed from the discipline of ship-board, he has plenty of money in his pockets, and he sets to for a lark, and makes a fool of himself, till his money is spent, and then he is very poor, and sick, and seedy, and cross, and disgusted with himself—and longs to get a fresh ship and fresh work again—as a great many fellows I suspect long for the holidays to be over. They suddenly change the regular discipline and work of school for complete idleness, and after the first week is over, they get very often tired, and stupid, and cross, because they have nothing to do, except eating between meals and tormenting their sisters.

How much better for them to have something to do like this. Something which will not tire their minds, because it is quite different from their school-work, and therefore a true amusement, which lets them leave the muses for awhile, and something which they can take a pride in, because it is done of their own free will; and they can look forward to putting their gains in the museum when they come back, and saying, 'This is my holiday work, this is what I have done for the college since I have been away.'

Take this hint for your holidays, and take it too for after life, for I am sure that if you get up an interest in this museum *here*, you will not lose it when you go away.

Many of you will go abroad, perhaps spend much of your lives abroad—and I am sure you will use the opportunities you will then have to enrich the museum of the College, and be its benefactors, each according to his powers throughout his life.

But there is one interest which I have more at heart—even more than the interest of Clifton College, much as I love it—and that is the interest of science herself.

Ah! that I could make you understand what an interest that is—the interest of the health, the wealth, the wisdom of generations yet unborn. Ah! that I could make you understand what a noble thing it is to be men of science, rich with the sound learning which man can neither give nor take away: useful to thousands whom you have never seen, but who may be blessing your name hundreds of years after you are mouldering in the grave, the equals and companions of the most noble, and the most powerful, taking a rank higher than the Queen herself can give, by right of that knowledge, which is power.

But I must not expect you to see this yet; all I can do is to hope that my words may be fulfilled hereafter, that this museum may be the starting point of a school of scientific men—few it may be in number, but strong, because bound together by common affection for their College and their museum and each other—scattered perhaps over the world, but communicating their discoveries to each other without jealousy or dispute, and sending home their prizes to enrich the stores of their old museum, and to teach learning to the generations of lads who will be here while they are grown men doing the work of men over the world.

Ah! that it might so happen—ah! that even one great man of science might be bred up in these halls—one man who should discover a great truth or do a great deed for the benefit of his fellow men!

If this College museum could produce but one master of natural knowledge like Murchison or Lyell, Owen or Huxley, Faraday or Grove, or even one great discoverer like Ross or Baker or Speke, who has just solved the mystery of ages, the mystery after which Lucan makes Julius Cæsar long as the summit of his ambition—to leave others to conquer nations while he himself sought for the hidden sources of the Nile,—or if it should even produce one man able and learned enough to do such a deed as that performed by my friend Clement Markham, who penetrated, in the face of danger and death, the trackless forests of the Andes, to bring home thence those plants of Peruvian bark, which now, planted into Hindostan, will save the lives of tens of thousands, English and Hindoos, —then all the trouble, all the care, which shall have been spent on this museum—I had almost said, upon this whole College—will have been well repaid.

MEETING, Oct. 14, 1869.

The President exhibited a box of insects, presented by W. Claxton—a sea mouse (*Aphrodite aculeata*)—and a common barnacle (*Lepas anatifera*), presented by D. Walsh, Esq., and various other articles presented to the Society. He then read a paper on the Geology of the neighbourhood, illustrating it with a map.

The following ordinary members were elected:—

Hooper,	Hutchinson,
Wills,	Wintle,
Nash,	Brodie.

Present, 17 members and visitors.

MEETING, Oct. 28, 1869.

The following were elected ordinary members:—

Paul,	Spicer,
Smith,	Stone.

The following paper on 'Insect Parasites,' was read by the Rev. W. W. Spicer, M.A.:—

A CHAPTER IN THE LIFE HISTORY OF INSECT PARASITES.

All insects, as you are no doubt aware, suffer greatly from the attacks of parasites; that is to say, they are very liable to be preyed upon, during their lifetime, by animals nearly related to themselves. Whether they are feeders on flesh or on vegetable substances—whether they are soft-bodied, like the *Aphis*, or with a hard, almost metallic, surface like many of the beetles—whether they are in an imperfect state as a caterpillar, or their organisation be complete, all these various conditions seem to make no difference. At every turn an enemy awaits them, as cunning and active as themselves, which either fixes itself to the outer surface of their bodies and sucks out the internal juices through a powerful rostrum or beak, or else by means of a long piercing ovipositor inserts an egg beneath the outer skin, from whence proceeds

a larva, destined to revel on the fatty matter by which it finds itself surrounded. Nor is this all: the parasites are themselves liable to have their progeny pierced and devoured by other parasites, even to the third degree. Thus, the common plant-louse or *Aphis*, which extracts the juice from so many of our flowers and vegetables, is constantly attacked by various species of a parasite named *Aphidius*, wich is in its turn preyed upon by a third enemy, an *Asaphes*; the *Aphis* being pierced and used as a nest by the *Aphidius*, and the latter, while still inside the *Aphis*, being treated in the same manner by the *Asaphes!* So that, after all, there is no exaggeration in Professor Daubeny's well known *jeu de mot:*

> Great fleas have little fleas upon their backs, to bite 'em;
> And little fleas have lesser fleas; and so *ad infinitum*!

Few persons, whether strictly entomologists or not, but must have noticed the swarms of lice (as they are usually called, although in fact belonging to the *Acari*, or mites), known as *Gamasus coleoptratorum*, which infest the common dor beetle (*Geotrupes stercorarius*), whom we so often, on a warm summer's evening, hear 'droning' through the still air, or, it may be, feel, as it knocks against our hat. A still more curious parasite, though nearly related to the last, is *Uropoda vegetans*—(like most of these tiny organisms, it has no native name). I found specimens of the *Uropoda* a short time ago, attached to the under surface of a beetle (*Hister unicolor*). Parasites generally trust to their claws for a firm foothold, but *Uropoda* is gifted with the power of throwing out a veritable cable from near the apex of its abdomen, by which it moors itself to the beetle, just as a ship in the Arctic Seas is often moored to an ice floe. The tiny cable is apparently of the same substance as a single strand of the 'byssus' of a mollusc, and is so strong and elastic as to make it a matter of some little difficulty to detach the parasite. I find that Curtis, the well-known entomologist, figures and describes another species of *Uropoda*, which he found fixed to the back of a click beetle (*Elater*), and which he named *U. umbilica*, whose structure is even more curious than that of *U. vegetans*, for the cable by which it is moored issues from the middle of its back; it then makes a curve or arch, and finally glues itself on to the hard wing-case of the unfortunate *Elater*.

There are other parasites which do not themselves prey upon insects (at least not in their perfect condition), but

they deposit eggs in the bodies of their victims, which eggs develope into parasitical larvæ. This department of entomology is well worth studying, as it opens up facts of the highest interest. You can scarcely collect a series of cocoons without finding some parasite in attendance on the inmates. About a month ago I gathered two or three heads of the common yellow toad flax (*Linaria vulgaris*), the seed vessels of which were evidently infested with some insect. I placed the heads under a tumbler, with a glass over it. (I may mention *en passant*, that this forms a convenient 'breeding cage' for small objects, as every movement and every change of the little prisoners can of course be watched with the greatest ease; moreover, if the bottom of the tumbler be lined with an inch or two of damp earth, the ends of the leaves or twig on which the animals feed can be inserted, and thus kept alive and fresh for a long period, the cover preventing evaporation.)

In a few days I saw numbers of a small, dark-coloured rhyncophorous beetle wandering over the sides of the tumbler, which I was able to identify as *Gymnetron* (or *Rhinusa*) *antirrhini*; but, besides the beetles, there were at least as many specimens of a tiny hymenopterous insect (I believe, an *Alysia*), with most delicate legs and antennæ, and with wings which, under the concentrated light of the microscope, glittered with the lustre of the most gorgeous jewels. Nearly the same circumstances occurred on watching a head of stinging nettle, and another of the common furze, each of which was crowded with dark-coloured *Aphides*. In this case, however, the robber ichneumon fly issued from the adult *Aphis*, instead of from the helpless pupa. A curious sight, by the way, is an *Aphis* after its destroyer has made its escape. The little animal appears to have been quite unconscious of the enemy's presence, and to have sucked at the plant before it up to the last moment of its sluggish existence. Its rostrum is still fixed in the rind; its legs are planted in their natural position, as firmly as ever; save that the body has assumed a light brown hue, the casual observer would see no difference. But, for all that, life has gone; the animal is a mere hollow shell, and a small round orifice in the back marks the spot whence the intruder has crawled forth after it has done its deadly work.

But parasites do not always, as in the foregoing case, lay a solitary egg in their prey. Two or three larvæ of the common cabbage butterfly (*Pontia brassicæ*), which I collected this year, gave birth each to forty or fifty tiny parasites,

which worked their way out, one here and another there, from different points in the caterpillar's soft body. However, if we may judge from appearances, the latter was scarcely conscious of discomfort, far less of pain, from the inroads of its strange guests. Its manner of life underwent no change, and it wandered lazily and aimlessly about its prison, as heretofore. True, it ate no food; but caterpillars, be it remembered, take no sustenance for some little time before either of their transformations: and not the least wonderful part of parasite history is, that the date of the deposition of the egg is so admirably timed that the grub is able to emerge from the body of the caterpillar just when the fatty substance on which it feeds would naturally begin to fail. In other words, just when the animal would, if uninjured, begin to assume its chrysalid dress. This exact 'fitness of things' runs through all the insect world. As far as observation has extended hitherto, it is invariably found that there is no waste either of time or matter in Nature's works. We have an analogous instance in the case of sand wasps, which lay up a store of spiders, flies, &c. for the use of their young. Their manner of proceeding is this:—Each kind of sand wasp has a *penchant* for a particular insect, and confines itself to that. Thus, *Philanthus triangulum* seizes on honey bees, *Mellinus arvensis* on flies, &c. The economy of their doings is illustrated by the fact that, on seizing a victim, the sand wasp does not slay it at once, but only stings it in a modified form, so as to paralyse it, and render it helpless. And why? Because at this period there is an egg only in the cell of the robber wasp. Were the victim, therefore, put into the cell dead, it would dry up or become corrupt before the young wasp could take advantage of the prepared banquet. As it is, the unfortunate spider or fly remains alive, though utterly unable to escape, until the little savage for whose benefit it has been deposited emerges from its egg. A second illustration of the accurate balance preserved by Nature in the supply and demand for food among her children is, that exactly when the victim is devoured, the time has arrived for the larva of the sand wasp to pass into its chrysalis state, in which it rests, as in a temporary grave, with neither the desire nor the power to eat.

To return to our ichneumon fly. It is a noteworthy circumstance (appropriate, too, to the subject of supply and demand) that, although it spends weeks, perhaps months, inside the caterpillar, gnawing and devouring in every direction, it all the time carefully avoids injuring any vital part,

such as the ganglia or tracheæ, as though conscious that its own existence depends on that of its host.

The time for the exit of the little grubs having arrived, each one, as it issued forth, attached itself to a neighbouring grass-stalk, and there spun a cocoon of the purest light yellow silk, very similar to that of the silkworm, but, of course, on a very reduced scale. In a few days these cocoons gave birth to a four-winged hymenopterous fly, known as *Microgaster glomeratus*.

All these instances, and myriads of a like kind, have been known to naturalists for a long period; but there are others, similar in principle, though varying greatly in the manner in which they are carried out, which have but lately yielded up their secrets to the long-continued observations and patient researches brought to bear upon them. Witness the remarkable results which have been elicited by Mr. Newport in England, and, after him, by M. Fabre in France, in regard to the cantharidæ, a family of bettles, including the blister fly (*Lytta vesicatoria*), the oil beetle (*Proscarabæus*) and a few other genera.

Everyone, I think, must be acquainted with the 'common oil beetle;' at any rate, there must be few who have not seen it wandering slowly along some sunny bank in early spring; a fat-bodied insect, an inch or more long, of a black hue, with a purple sheen on its armour-like surface: it has no true wings, and its short elytra, or wing-cases, scarcely reach half the length of its back, at least in the females. Moreover, if curiosity has led you to take it up from the ground, you will not have forgotten the yellow oily drops which the animal discharged from every joint, and which has earned for it its native name. I suppose it is impossible to pitch upon any two animals which are apparently more widely separated by Providence, as regards structure and habit, than this wingless, slow-moving beetle, and the active intelligent bee; and yet, in one stage of their existence, there are no two animals more closely connected. This strange fact comes about thus. When we see the female oil beetle making its way over the turf or by the side of a path, she is, generally speaking, in search of a spot wherein to deposit her eggs, and she lays about 2,000 in different places—a hundred or two at a time—before she has done. Within a month or six weeks from the time the eggs were placed in the ground, the young larvæ make their appearance, lively, fast-running little creatures, whose first impulse is to leave mother earth, climb up a flower stalk, and ensconce

themselves within the folds of the corolla—not, indeed, to feed on the flower, nor even on the pollen—but for a totally different purpose: the flower is merely a station on their railroad of life. Very shortly the train arrives, in the form of a bee, to which the larvæ fearlessly attach themselves by their claws, and are incontinently carried off. But the embryo oil beetles are dainty travellers; it is not every bee that will suit their purpose. The honey bee, although in the nature of things the most frequent visitor of flowers, is carefully eschewed, and allowed to come and go unmolested. Those species only are selected which make their nests below the ground, or in some similar situation. Can it be that these minute insects are warned by that most mysterious endowment—instinct—(a quality so far below, and yet so far above, reason) that were they to follow the fortunes of the hive bee, they must with it be prematurely cut off by man's art? Be that as it may, it appears to be well ascertained, that altogether neglecting *Apis mellifica*, the larvæ cling only to such species as do *not* dwell in hives, and have never been taken under the guardianship of man, such as *Osmia*, *Eucera*, *Melitta*, *Andræna*, &c.

The fact of these larvæ being found on different kinds of bees was known to the earlier naturalists; but until Mr. Newport took the matter in hand, the character of the animal itself, and the purpose for which it took up its abode on the bees, were alike misunderstood. Even so late as the publication of Kirby and Spence's 'Introduction to Entomology' (1815), it was thought that they were completely formed animals, belonging to the section *Pediculi*, or lice. In fact, they were named by Kirby '*Melittophagus melittæ*,' having been previously christened by Dufour, '*Triungulinus apium*;' there was not a suspicion entertained by these accurate observers that the insect was only in an intermediate stage of transformation. Under date of May 7, 1812, we find Kirby making the following entry in his common-place book: 'On the flowers of *Ficaria*, *Taraxacum*, and *Bellis*, I found a great number of this insect, which seemed extremely restless, running here and there over the flowers, and over each other, with great swiftness, mounting the anthers, and sometimes lifting themselves up above them, as if looking for something. One or two of them leapt upon my hand. Near one of these flowers I found a small *Andrena* or *Halictus*, upon which some of these creatures were busy, sucking the poor animal, so that it seemed unable to fly away. When disclosed from the egg, I imagine they get on the top of

these flowers to attach themselves to any of the *Andrenidæ* that may alight on them, or come sufficiently near for them to leap on it.'

Once back in her own nest, the bee has no need to take pains to rid herself of her strange burden; the larva is now as anxious to quit the carriage as it was before to find a seat in it; therefore, no sooner is the subterranean terminus reached, than the ill-assorted couple separate, the young oil beetle dropping into a cell, where it takes up its abode for the next nine or ten months.

But there is another phase in this singular life history which must not be forgotten. The bees have among themselves, and of their own order (the Hymenoptera), certain members who are unable, from the structure of their feet (having rounded instead of flat tarsi), to lay up a store of pollen. Taking advantage, therefore, of their relationship to honey-making bees, these *Cuculinæ*, or cuckoo bees (as they are aptly denominated by Latreille), deposit their eggs in the well-stored cells of some industrious earth-burrower. Strange to say, the true bee sees nothing odd in some of her cells being already occupied, but passes on to another, and in the end pays as much attention to the little strangers, and lavishes as much care upon them, as does the hedge sparrow on the young of the cuckoo among birds. But although thus incapacitated by their peculiar conformation from undertaking the cares and the duties of a nursery, these insect cuckoos in other respects behave themselves after the fashion of bees generally, frequenting the flowers and burying themselves in the rich pollen, as though they were the most active collectors of honey in existence. This brief account is meant to preface the curious fact, that the young oil beetle is perfectly conscious that if he attaches himself to a cuckoo bee, he will be borne to his destination as surely and as speedily as though he were riding with the rightful owner of the nest. Accordingly he lays hold of a *Nomada* or a *Cœlioxys* as readily as he does of a *Eucera* or an *Andræna*.

But there is yet another, and still more striking, stage in 'this strange eventful history.' Among the numerous enemies which prey upon bees is an elegant two-winged fly, called *Volucella*; one of the species is not uncommon in gardens, darting from flower to flower, and conspicuous by a broad yellow band which traverses the dark-brown ground of its body. From the rapidity of its movements and the transparency of this coloured band, it is well named *Volucella pellucenos*. Not that the fly itself ever destroys the

bees; it is its larva which works the mischief, fastening itself on the grub of the bee and sucking out its juices. To effect this object, the female *Volucella* on discovering a bee's nest, walks boldly down the passage leading to it, and there deposits an egg on the skin of the baby bee, whose doom from that moment is sealed.

Will it be believed that our tiny oil beetle, as if aware of this peculiar habit of the *Volucella*, attaches itself to it in order to be carried to a bee's nest? Yet such is, in fact, the case. Flies, as we all know, surround the flowers in early summer (when these circumstances occur) in myriads. How shall our inexperienced bantling distinguish one species of fly from another? We cannot tell. We can only fall back once more upon instinct, not to solve the mystery, but only to express our ignorance in a form less displeasing to our vanity! However, be the solution what it may, the fact remains that the larva of *Proscarabæus* attaches itself to an insect with which it has nothing whatever in common, except the one circumstance, that both are desirous to find their way into the cell of an earth-burrowing bee! Having by these various means landed our young friend in its temporary home, but little more remains to be said. Snugly ensconced in a cell, it first devours the helpless bee grub, and then (in a later stage) eats up the prepared pollen or bee bread intended for the rightful occupant of the cradle. Thus it passes through four transformations, unmolested by the inmates of the nest, and in the following spring issues forth a perfect beetle, prepared once more to play its part in the great drama of Nature. I think you will agree with me, that we have here as strange a chapter in the Life History of Insect Parasites as the imagination can well conceive, and one which shows in a very extraordinary manner the abundant care which the Almighty takes of the meanest of His creatures.

Note.—One or two other meetings were held during the latter part of 1869, but the minutes, unfortunately, have not been preserved. One of the papers then read was by J. E. Pearson, on the 'Atlantic Telegraph.'

MEETING, Feb. 4, 1870.

The President congratulated the Society upon the addition to its ranks of Mr. Barrington Ward, and proposed that he should be elected a second secretary. The proposition was unanimously carried. Mr. E. O. Ashby read a paper on the 'Induction Coil,' illustrating it with various experiments.

Ordinary members elected :—

Robinson. Anderson.

Present, 17 members and 38 visitors.

MEETING, March 10, 1870.

In the absence of the President, Dr. Debus, Mr. Barrington Ward took the chair.

Ordinary member elected :—

W. Ffooks.

Honorary members elected :—

Rev. H. J. Wiseman. F. H. Talbot, Esq.

Present, 29 members and visitors.

T. H. Warren read the following paper :—

ON BATS.

Perhaps no order in the animal kingdom has given naturalists more trouble than that of the bats, or, as they are scientifically termed, the Cheiroptera. The popular idea is that they are a sort of combination of the quadruped and the bird; and, from their resemblance to a winged mouse, they are sometimes called flittermice. There was, indeed, a system once current among naturalists which placed the bat and the ostrich in the same order, because the bat could fly, while the ostrich could not. Even after their true mammalian character had become better recognised, they were placed at the end of the mammals, and considered as a link between them and the birds. Though few, however, would now think that a bat is a bird, we must allow, at least, that the bat discharges by night that office which is filled by the swallow during the day. Indeed, we can show that in every great division of animals there are individual forms endowed with characters which, to a casual observer, might appear to

place them in a wholly different set. Thus we find mammals which can fly (as those at present under consideration), mammals which seem practically fishes, and live a purely aquatic life (e.g., the Cetacea, or whales). There are also some mammals of low type which approach very nearly to reptiles.[1] Then, again, we find, among birds, the ostrich, which, besides being unable to fly, possesses various developments of its internal structure that show no small resemblance to those of mammals. Among reptiles, there is a curious little animal which is provided with a membranous development very much resembling that of the flying squirrel, and by means of this it can launch itself for a considerable distance through the air.[2] Among the antediluvian reptiles we find an order (the Pterodactyls) in which the flying power was still more fully developed, perhaps as much as in the bats. Then again, among the fish, we even find some which possess the power of walking on dry land beneath a burning sun, and even remaining five or six days without water;[3] so that 'a fish out of water' does not always apply. Flying fish are too well known to need comment. This sort of law or arrangement will be seen on closer examination to exist in the smaller differences of genera and species, as well as in the more general ones of which we have been treating, but we have not at present time to follow this subject out, and so will proceed to that in hand.

There is a certain strange and not generally known animal called the flying lemur, or Colugo, which lies on the border-land between the Quadrumana and the Cheiroptera. While in many respects strongly resembling the lemurs (which themselves are but an aberrant form of monkeys), the Colugo is provided with a membrane uniting the limbs and tail, with which it is enabled to fly, or rather float, a considerable distance through the air. Like the bats, too, it is in the habit of sleeping and resting suspended by its hinder paws. I have mentioned this animal as a sort of introduction to the true bats, which must now be considered.

In looking at the bat, we are naturally led, first, to consider the means by which it is enabled to fly. This we find to be a membranous prolongation of the skin of the flanks and other parts, which stretches round the body. To support

[1] The Monotremata (*Ornithorhynchus* and *Echidna*) have distinct reptilian affinities.

[2] The 'Flying Dragon' (*Draco volans*). *Vide* a paper by J. F. M. H. Stone, in this volume.

[3] The Climbing Perch of Ceylon (*Anabas scandens*).

this membrane the bones of the fore part of the body are singularly modified. Those of the fore-arm are very much elongated, while that bone called the ulna (used along with the radius to turn the hand) is either very small or else absent, since, of course, a steady, and not a rotating stroke is required for any continuous flight. Perhaps, however, the strangest modification is found in that part which corresponds to the hand of a man or a monkey. This member, which becomes the paw of some quadrupeds, the hoof of others, the flapper of a seal or a whale, the fin of a fish, is, in the bat, developed so as to form a means of flight. In the first place, all the fingers are prolonged almost indefinitely, the middle one being of a greater length than the whole body. The thumb is very short, but is provided with a curved claw, by means of which the bat can drag itself along the ground. The bones of the breast and its neighbourhood are also altered so as to support the muscles of the wings, this development being more apparent in the insect-eating bats than in the fruit-eating species, as the former have more need of swift flight. The breast bone, too, is very strong, and exhibits a ridge or keel not unlike that which is found in the sternum of birds.

The hind legs and feet appear weak and little developed, when compared with the fore parts of the body of which we have just been speaking. There is, however, one peculiarity of the feet which is certainly worthy of notice. This is a peculiar development, or 'tuberosity,' as it is called, of the heel bone, which forms a kind of thin bony spur, running between the double membrane towards the tail.

Having now glanced at the formation of the skeleton, we will proceed to other characteristics of the family of bats even more curious, namely, the development of the organs of the senses. The eyes are exceedingly small in the insectivorous species. The organs of hearing, on the contrary, are very highly developed. The ears are double, consisting of an inner and an outer ear, and they are not unfrequently very large, being sometimes apparently quite out of proportion to the rest of the body. The inner ear is very large—larger relatively than in almost any other animal. Its use seems to be to guard against the rush of air during flight. While at rest, the outer ears are folded back, and the inner alone exposed. But, besides the senses of hearing and sight, bats seem almost to have an extra sense peculiar to themselves. Indeed, this was at one time considered to be the case, though now, however, it is supposed to be only the

sense of touch very highly developed. A naturalist called Spallanzani found that bats were able, after being deprived of the senses of sight and hearing, to fly with the greatest accuracy, avoiding even numbers of small strings which he had stretched across the room. Cuvier, however, seems to have satisfactorily accounted for this power, by supposing that the flying membrane itself was endowed with the most exquisite tactile sensibility, which its anatomical structure appears fully to bear out.

The hair of bats, too, though apparently much the same as that of mice or rats, when examined under the microscope, exhibits some peculiar and remarkable features. Each hair is covered with a regular series of scales, arranged round a central shaft.

We shall now pass on to consider some of the species of bats, of which at least nineteen have been enumerated. There are several kinds of bats belonging to this country. One of these is the Great Horse-shoe Bat.[1] It may be recognised by the absence of the inner ear, and by the leaf-like appendage found on its nose. Another, and perhaps the most common, is the Long-eared Bat,[2] remarkable, as its name implies, for the extreme length of its ears. The largest British species is the Large-eared Bat.[3] The greatest of all bats are the Kalongs, or, as they are often called, Flying Foxes.[4] Some of these species measure over five feet in expanse of wing. Their food is fruit.

We now come to what will, I think, form an appropriate termination to this paper, namely, a short notice of the celebrated Vampire Bat.[5]

The Vampire Bat is a native of South America. It is not a very large animal, the spread of its wings being only about two feet. Many horrible tales you have no doubt often heard told of this dreaded animal: how it settled on the exposed toes of the sleeper; and how, after having with its sharp teeth inflicted a slight and imperceptible wound, it then commenced draining the very life-blood of its victim, alternately sucking and disgorging its meal; and how it went on with its revolting repast until its wretched victim perished from exhaustion. The fact seems to be clearly proved that the vampire frequently attacks both man and beast, but at

[1] *Rhinolophus Ferrum-equinum.* [2] *Plecotus auritus.*
[3] *Myotis murinus.*
[4] *Pteropus.* There are two fine specimens of *P. rubricollis* in the Clifton College Museum.
[5] *Vampirus spectrum.*

the same time it is also as certainly proved that the wounds are *never* fatal. Nor are vampires so rapacious as they are described, for Mr. Waterton, desiring to experience an attack, slept for eleven months in an open loft, yet without success, though other persons sleeping a few yards off suffered repeatedly. An unfortunate jackass, meanwhile, was being killed by inches, and was so far reduced by the nocturnal assaults committed on it, that, in Mr. Waterton's own words, he appeared 'like misery steeped in vinegar.'[1]

MEETING, March 24, 1870.

Dr. Debus, President, in the Chair.

The minutes of the last Meeting having been read and confirmed, J. Stone read a paper, of which the following is an abstract, upon 'Butterflies and Moths.' The opening portion was devoted to an explanation of the structural formation of butterflies and moths in the perfect state. This was followed by an account of their transformations from the egg, through the larval and pupal stages, to maturity. In describing the second of these stages—i.e. the larval—the writer referred to the extraordinary manner in which the undue increase of lepidopterous caterpillars is arrested, viz. by the deposition within their bodies of one or more eggs, by certain hymenopterous and dipterous insects, familiarly known by the name of Ichneumons. Having given some instructions as to the best methods of capturing, setting, and preserving insects, the writer brought his paper to a close with a few observations upon some of the common species of British butterflies.

On the motion of the President, a vote of thanks was unanimously passed to J. Stone, who had presented a large case of British butterflies to the museum.

A paper was then read on the 'Mollusca,' by A. Cruttwell, and some typical specimens of the various classes were exhibited.

Mr. Barrington Ward exhibited an emu's egg and a specimen of the Duck-billed Platypus (*Ornithorhynchus paradoxus*).

[1] *Essays on Natural History*, by Charles Waterton.

The following new members were elected:—

Honorary.—Rev. J. Greene, M.A.

Ordinary.—C. B. Brownlow, J. Duncuft,
L. B. Ffooks, C. Brittan,
J. Heath, C. Whitty,
W. Hughes, F. T. Saunders.

Present, 36 members and visitors.

MEETING, March 31, 1870.

Dr. Debus, President, in the Chair.

The minutes of the previous Meeting having been read and confirmed, C. T. Blanshard read a paper on 'Food.'

The writer opened his paper with a statement of the chief functions of food, explaining more fully its use as a source of heat, and comparing it to the fuel of a steam-engine. He then went on to describe the process by which food is converted into blood. The following is an extract:—

'All the bodies that can be taken as food may be classed under four heads—firstly, those which are termed proteids; secondly, fats; thirdly, amyloids; and fourthly, minerals—that is to say—minerals contained in either animal or vegetable products; for those which are not in such a condition are mostly injurious. To the class proteids belong the fibrin of the blood, syntonin, the constituent of flesh and muscle, the gluten of flour, albumen, casein, and some other substances having very nearly the same chemical composition. All these contain carbon, oxygen, hydrogen, nitrogen, and, in the case of some, sulphur and phosphorus also. Fats and oils are composed of carbon, hydrogen, and oxygen only, and are the more important, inasmuch as they produce heat, rather than for the small amount of tissue that they are able to form. Amyloids are bodies also useful for the production of heat, consisting of the same elements as the fats; but the amount of hydrogen and oxygen in them is in the same ratio—that of two to one—as it is in water. To this class belong starch, sugar, and gum. There are many mineral substances contained in the human body, the chief of which are phosphates, calcium, fluorine (found in small quantities in the bones and brain), sulphur, chloride of sodium, iron (which is supposed to impart the red colour to blood), salts

of potassium, magnesium, and silicon, which forms a part of the hair, teeth, and nails. There is also a great quantity of water in the human body, so much so that three-fourths of a man's weight is only water.'

A few remarks on the foregoing paper having been made by the President, the following Rules, which had previously been prepared by the Committee, were submitted to the Meeting :—

I.—'That the officers of the Society be, a President, Secretary, Treasurer, and three extra members of Committee.

II.—'That the President and other members of the Committee be elected by the Society, with the exception of the Secretary, who shall be invariably chosen by the Committee from its own members.

III.—'That an election of officers do take place at the last meeting in each term, and that all officers be elected for one term only. This latter clause shall not, however, prevent the re-election of any member or members.

IV.—'That the Committee be empowered to fill up all vacancies which may occur during term.'

The above Rules having been passed unanimously, the election, by vote, of the officers for the ensuing term, was proceeded with. The six following were chosen :—Mr. Barrington Ward, Dr. Debus, T. H. Warren, J. E. Pearson, W. Claxton, and Rev. J. Greene.

After a poll held for the purpose, Dr. Debus was elected President, Rev. J. Greene, Treasurer, and, at a meeting subsequently held by the Committee, Mr. Ward, Secretary.

The following were elected ordinary members :—

J. Douglas,	R. G. Robertson,
J. Fox,	C. S. Penny,
A. H. Groom,	G. F. M'Corquodale,
S. H. Leonard,	W. S. Smyth,
T. L. Jenkins,	G. H. Smyth.

Present, about 40 members and visitors.

MEETING, May 20, 1870.

Mr. Barrington Ward in the Chair.

A paper was read by W. Claxton on the 'Hawk Moths,' of which the following are extracts:—

'The general types by which they may be recognised are the long pointed wings, which are most readily observable in the larger species, since in the smaller kinds the wings are not so pointed; the robustness of the body or abdomen, and the extraordinary length of the spiral tongue, which, in the larger members of this family, is equal to the length of the abdomen—with one remarkable exception—the Death's Head (*Acherontia atropos*), the tongue of which is only as long as the head, though the moth itself is the largest of British insects. The greater number of Hawk Moths fly in the dusk of summer evenings. . . . The total number of moths belonging to the family which we are considering is sixteen, if we omit the Burnets and Clear Wings; though, by some authorities, this number is increased by the addition of specimens, which are almost unique, having probably flown over from the continent, a voyage which these insects are quite capable of undertaking, and often carry out. . . . There has been a great diversity of opinion as to the manner in which this squeaking sound (made by the Death's Head) is produced. Reaumür occupied himself very assiduously in endeavouring to arrive at a satisfactory conclusion on the subject, and at last decided that it proceeded from the mouth. The insect, in common with other moths, has two short feelers or palpi in front of its head, and between these is situated the trunk or tongue. Reaumür thought that it rubbed the trunk against the feelers, and that the squeaking proceeded from this friction. He straightened out the curved proboscis with a large pin, and as often as he did so the squeaking ceased, and was renewed again directly he allowed the proboscis to resume its usual position. He next separated the feelers widely, so that they could not touch the proboscis, and this also stopped the sound; he then cut off one of the feelers, and the sound was scarcely audible. Other entomologists have held different views, and I do not know whether the question is settled yet. This insect varies in size from four to nearly six inches in the expanse of the wings.'

At the conclusion of his paper, the writer warned the younger entomological members against the practice of *buy-*

ing rare insects. Owing to the high price often given for rarities, unscrupulous dealers frequently palmed off upon the inexperienced, foreign specimens as British, and as an instance of the high prices sometimes paid, he mentioned, on the authority of a friend who had been present, that at an auction of British Lepidoptera, two little moths, barely a quarter of an inch in expanse of wing, fetched the sum of 11*l.*

The Rev. J. Greene invited any members, who might feel disposed, to inspect his collection of British Lepidoptera, on Saturday, May 28, at 3 P.M.

Mr. Ward then gave the following lecture on

THE HABITS OF THE BEAVER.

A great deal has been written in books of popular Natural History on the habits of this curious animal, and there are few who are not acquainted with some details respecting it. But the common accounts are too often flavoured with so much romantic and incredible spice, that one would feel inclined to believe that the famed Baron Munchausen had had a share in the composition of them. The habit of embellishing and adorning is unfortunately but too apparent in most of the works of those who profess to write scientific matters in popular language, and most of all, in the universally favourite pursuit of Natural History, those who compile *ad populum captandum* often excel in their ingenuity the most daring romance writers, and in their inaccuracy reveal to the scientific eye their unfitness for the task they have undertaken.

I am especially led to make these remarks from the fact that I have recently had occasion to look over many works of the class I have above alluded to. I mean popular books of Natural History, and I have been profoundly struck, over and over again, with the frequent fabrications, the still more numerous inaccuracies, and the everywhere apparent obscurities which so large a proportion of these accounts contain. To the Beaver, as I have already said, an amount of sagacity is commonly attributed far beyond the real state of the case. One would almost think, to read some of the pretty stories that have been told about it, that the Beaver was endowed with an understanding and powers of reasoning in advance of the intellectual qualities of many sensible men. Yet I am far from saying that there is not some foundation for all these tales: the fabric has a foundation of truth unquestionably, but it is the superstructure and its embellish-

ments which have obscured the original. There is indeed so much that is remarkable in the habits of the Beaver, that they cannot fail to prove interesting to anyone, even when divested of all that imagination has added to them, and narrated in the plain language of truth.

For much recent information on this subject we are indebted to Mr. Ashdown Green, an old trapper well acquainted with the Canadian hunting grounds, and to Mr. Robert Brown, who has spent much time in the wild districts of British Columbia and Vancouver's Island. These gentlemen have recently communicated a joint paper to the Linnæan Society,[1] containing many points of interest previously unnoticed, and contradicting a considerable number of the statements in current acceptation. From this source, and from some other authentic information, I have mainly compiled the substance of the following account.

The Beaver is found plentifully throughout Canada, and indeed over the entire northern part of the American continent. Like most other animals of far northern latitudes, it is found in the Old World as well, being frequently captured both in Siberia and the north of European Russia. It has been also recorded as existing plentifully on the banks of the Euphrates, while colonies of it undoubtedly exist on the Nuthe, a tributary of the Elbe, and isolated individuals are met with on the Rhone, and perhaps also on the Danube. This animal is, then, by no means limited in its area of distribution, and in former times it spread over even more extensive regions. Old traditions, supported by historical records, show that the Beaver was once an inhabitant of Great Britain and Scandinavia. Indeed it has only comparatively recently become extinct in Scotland, for in a translation of Boëthius' 'Croniklis of Scotland,' published by command of James V. in the middle of the sixteenth century, the animal is mentioned without hesitation as having existed in the Highlands, and could we only accept Highland tradition as truth, we should have to say that it was found at Lochaber long afterwards. Such evidence, however, requires to be taken *cum grano salis* in a case where the Scotch national pride is involved; yet it is interesting to observe that a special Gaelic word for the animal is, or was lately, in use (Losleathan), signifying the Broad-tailed Otter. In the curious old story of 'Giraldus Cambrensis,' written about the year 1158, and recording the events of a journey made

[1] *Journ. Lin. Soc.* vol. x. No. 46, 1869.

throughout Wales, along with Baldwin Archbishop of Canterbury, we learn that the Beaver was still found in the river Teify in Cardiganshire, and the writer gives an account of its habits there, derived from his own observations. But Boëthius, the Scottish chronicler already mentioned, speaks of the *fibri* (the term by which he calls the Beavers) as existing in great quantities in his own time on Loch Ness, and says that their fur formed an important article of export.

Whether or not the British, Scandinavian, Germanic, Siberian, and American Beavers be of the same species has never yet been ascertained for certain, but it is believed that there are perhaps hardly sufficient points of difference between the Old and New World forms to separate them into the two species, Castor fiber and Castor Canadensis. The European Beaver, like its American relation, shows a propensity for building and sociability, and the structural points of difference between them seem really very small.

All over the lakes, creeks, and rivers of British America, wherever cultivation and the civilising hand of man have not as yet made their way, the Canadian Beaver is to be found. Though there are many isolated individuals, the animal lives usually in societies, varying greatly in number. Eight to twelve, however, is perhaps about the average in each colony. The situation chosen for the settlement is very generally on some shallow stream where there is a current in the water, but they are found even on the sluggish water of lakes. An especially favourite spot is one of the many creeks which form so striking a feature in Canadian scenery. Innumerable lakes cover a great part of the face of this interesting country, and they are connected by brooks, falls, and channels in a labyrinthine confusion. Indeed the rivers themselves many a time widen out to form great pools often miles in length, and as suddenly narrow their limits into deep and rapid gullies. No part of the globe could be better suited to the wants of the Beaver race: the lake and stream, the uncleared forest, the wild solitudes untrodden by man, have all lent their aid to preserve and multiply the favoured animal, and, but for the persistent manner in which its hunting has been carried on during a long course of years, the Beaver would doubtless be even a commoner animal than it now is. Strangely can fashion influence the destinies of a race! The 'Beaver hat' of our grandfathers necessitated the production of a tenfold quantity of skins: Beavers every year became scarcer and dearer; trappers made fortunes and lived on the fat of the land; at no slight expense did

the English gentleman adorn his head with a skin-covered canister. Now-a-days, however, *nous avons changé tout cela*. The invention of the lighter and cheaper (if less durable) silk hat has caused the Beaver trade to languish and decline. Trapping is no longer a lucrative business, and few are engaged in it. The price of Beaver skins has fallen to a mere fraction of its former amount, and the consequence is that every day Beavers become more numerous, for the cessation of the demand has made the supply unnecessary.[1] It is curious also to notice how beneficial the discovery of the gold mines in British Columbia has been to the Beaver race. All accounts agree that the animals are now rapidly increasing there, for the trappers have found gold digging a more profitable employment than Beaver hunting, and have wisely relinquished their old calling.

The main object of the Beaver in forming its colonies would seem to be mutual protection and defence. When combined together the little society can more readily prepare for the rigours and dangers of winter than if its members were to dwell separately. So, long before the autumnal days have come, the Beavers begin to associate themselves in the formation of a dam, and even as early as August the work is usually well advanced. By this time the floods of spring have begun to subside, and the task is not so difficult as if it had been commenced earlier.

Whether the colony is to be placed by lake or creek, the water must at all events be of sufficient depth to prevent even the severest frost from reaching to the bottom. It is clear that the Beaver would find but little safety in its winter home, were it in danger of being locked in on the one side by deep snow, and on the other by solid ice. Hence the necessity of forming a dam, so that the water may be banked up to the requisite depth, and free swimming power secured for the entire winter. The length of the pool thus formed will vary from a few yards to many miles, according to the nature of the place, and not a little of the picturesque succession of lake and waterfall for which Canada is remarkable, must be attributed to the works of the Beaver, though of course the geological structure of the country has been the chief agent in their formation.

[1] Beaver was, in the height of the fashion, thirty shillings per lb. The Hudson's Bay Company will not give more than 75 to 85 cents for it now. Yet, even when dearest, it was not the poor Indian who reaped the profit. Beavers 'were piled up on each side of a trade gun until they were on a level with the muzzle, and this was the price! The muskets cost in England some 15s.'—R. Brown, *op. cit.*

The favourite site for a Beaver colony is a bend in a stream with high and clayey banks on either side. Here the current will offer the least resistance to the dam, and clay in abundance is forthcoming for its consolidation. The first step is to fell down a large tree at the selected site, or two, if the stream is a wide one. The trees are cut down so as to fall across the stream, and if the current is sluggish they may extend in a straight line from shore to shore; but if it be a rapid one and two trees have been employed, a sort of arch is at once formed, with the crown down the stream, an effect of course produced by the greater rapidity of the current in the middle.[1] The only perpendicular portions of this rude framework consist of the tree's branches—it is erroneous to say that the Beaver fastens any posts vertically into its dam. But the consolidation of the structure is secured in this way: many sticks (four to six feet long) are cut down some little way up the stream and are then freed of their branches, dragged into the current, and guided towards the dam. Here they are fastened together by means of mud, small stones, leaves, roots, &c., carried from shore by the builders, and very soon a great degree of resistance is afforded to the current, and the water speedily rises above the obstruction. The Beavers raise their dam still higher, and when the required level is attained they cease their work, leaving the rest to the action of the water itself. Great quantities of sand, gravel, or mud are soon deposited on its upper side by the stream, and any chance trees or branches which may float down help to make the dam still more complete. Bye and bye the sticks and logs of willow (which are sure to form part of it) take root, and send forth their shoots; decaying leaves begin to form a soil, vegetation appears, and the permanence of the whole dam is ensured. It is true that the recurring floods of spring often carry away large portions of the surface part, but the under structure generally remains proof against such attacks, and with the return of the building season the Beavers repair any inroads that may have been made.

The dams are often as much as three hundred feet wide, but their height above the water is inconsiderable, and their thickness is of course greatest at the bottom of the water. An opening in the centre of the dam permits the efflux of the current.

[1] Yet at least two writers on 'popular' Natural History state the very reverse, affirming that the convexity, and not the concavity, is turned towards the stream! It is difficult to see how this could be. On this point Mr. Green's evidence is more reliable (*vide op. cit.* pp. 363-4).

The Beaver lives both in burrows and 'lodges.' The former are generally found along the edges of rivulets, and they are often of some extent, communicating directly with the water, and having an opening for air on the land. It is perhaps most generally in the summer that these burrows are tenanted, but not unfrequently the trapper surprises Beavers in them in the midst of winter. The 'lodges' or 'houses' are found beside the dams, and as their mode of construction is a very interesting one, it will be worth while to describe it briefly.

It is a difficult thing to recognise one of these lodges at first sight. The traveller would seek in vain for the neatly-built and carefully-plastered houses which he had read of, and perhaps seen figured. A pile of sticks loosely heaped up here and there along the banks of the stream would be all that could attract his attention besides the dam itself. No wonder, for it is beneath these heaps of sticks that the lodges are to be found. They are very roughly built, merely consisting of piles of wood mingled with mud, stones, and roots, and much less care seems to be bestowed upon them than on the dam: for, indeed, all the Beaver wants here is a dry resting-place which shall open towards the water. The top of the house is very strong, thickly covered with mud and other materials, and it becomes as firm as adamant when the severe frosts of winter come on. As far as this portion of it goes, the lodge is quite impregnable, and the Beavers within it are safe from their dread enemy the wolverene.[1]

No doubt it is partly to conceal their lodges from view that the Beavers cover them with the piles of sticks mentioned above. The lodge generally is of a circular form, six or seven feet in diameter, and three in height. It projects altogether about four to six feet above water. The animals seem to do their building for the most part by night, but they are so easily alarmed that it is difficult at any time to watch their movements. So far as has been ascertained, however, they convey the mud and stones for their lodges between their throat and fore-paws, and the small logs they drag along by their teeth, having previously gnawed away all outstanding branches. When a trunk proves too much for one animal's strengh he is assisted by others, and the house is rapidly heaped up, the only precaution taken being that a circular hole shall be left in the middle. No such thing as 'plastering' takes place. The fables which have

[1] *Gulo luscus.*

been narrated about this have probably had their origin in the smooth tracks observed to have been made all round the houses by the Beaver's flat broad tail, and the flaps of it that the animal is seen to make when leaping from the bank into the water, or when excited by any cause. The entrance to the lodge is invariably at some depth beneath the surface of the water,—not on the very edge of the bank, but some little way underneath it.[1] There are usually, though not always, two flats in each house—the lower being a mere waterway intended to secure free and safe entrance to the upper one, as also to raise it above floods.[2] Four beavers generally occupy a house; sometimes only two. Each of them has a separate bed of grass, and the passage of communication to the waterway below is in the centre of the floor. There is always a passage leading to the land as well. The houses are occasionally joined externally, but are still perfectly separated within.

The food of the Beaver depends on the season: in summer he eats roots,[3] leaves and grass, but in winter he has to subsist on the bark of various trees, especially the willow and alder. There is but little nutritive matter in food of this latter kind, and it is no wonder that the return of spring finds the Beavers in a thin and emaciated condition. But they soon recover their flesh again and seem none the worse for their long enforced abstinence. A pile of sticks is said by some writers to be invariably laid up under water near the entrance of the lodge, so as to form a store for winter consumption. Pieces of branches and often whole trunks are, they say, submerged by means of stones and left beneath the water till required. But this seems incredible, for sticks placed in such a position must speedily decay, and bark when rotten would not feed even a Beaver. Indeed it is highly improbable that the animal lays by any store even on dry land (as the majority of naturalists hold), for, in the expressive words of Mr. Green,[4] 'one day's supply of sticks for a single Beaver would fill a house; and if a stick were cut in the autumn, before the winter was over it would have lost its sap, and would not be eaten by the Beaver.'

The gnawing power of the Beaver's teeth is something

[1] The trappers give the name of 'the angle' to the projecting ledge thus formed.

[2] This it does not always do. When the river becomes greatly swollen the Beavers are often obliged to leave their lodges and seek shelter in burrows elsewhere.

[3] That of the beautiful yellow water-lily (*Nuphar advena*) is an especial favourite.

[4] *Op. cit.* p. 362.

wonderful. Whole clearings are often made by the little animals in the forest, and the markings on the trees are said to be precisely like Indian 'chopping.' The felling process is a most ingenious one: the notches on one side are placed higher than those on the other, and thus a fall in any required direction is secured. The trees are always cut down *above* the lodges, and thence they are floated down the stream, one, two, or more Beavers directing the passage of the trunk, swimming beside it, and urging it towards its destination. The head of a large tree is invariably made to fall towards the land, and it is freed of its branches before being dragged into the water. The Beaver can snap through a branch as thick as a walking-stick at a single bite, and the cut is as clean as that of a chisel. Trees with trunks as thick as a man's thigh can also be felled in a few minutes by the action of the Beaver's teeth, and those of even larger growth are not insuperable obstacles to its rodent powers. One great objection to the domestication of the Beaver is the possession of these formidable incisors, for, though capable of being perfectly trained in other respects, it never forgets how to use its weapons. At Fort McLeod a tame Beaver sometimes amused itself 'in a very unpleasant manner, for occasionally, in the morning, the whole of the furniture was prostrate, the Beaver having gnawed through the legs of the tables and chairs!'

The hunting of the Beaver is generally conducted by the Indians in the following manner. They go cautiously along the edge of the ice, touching the frozen ground frequently with a stick. Whenever they know by the peculiar sound that they have found the land passage of a Beaver's burrow they plug it up and break into the cave below. Should the Beaver be away, they then quickly make a large hole in the ice, observing if the water below should become rippled, which would be a sure sign that a Beaver had just passed into it. Should it seek to regain its hole, either from land or water, it finds the passage blocked up, and is speedily shot ere it can escape. 'Trapping' is a different operation. For this, a supply of the powerful smelling 'castoreum' is to be procured. This is a glandular secretion, obtained from pouches near the base of the Beaver's tail: it was formerly used by perfumers and in medicine, but its use is now almost restricted to the trapping of the animal that produces it. A small quantity of the castoreum, steeped in rum and cinnamon, is smeared along the Beaver 'runs' (or paths). The trap—a good-sized steel one, fitted with a pair of strong

springs, and attached to a long pole by means of a chain—is then placed in the water, near the point whence the Beaver usually jumps ashore. The pole is driven firmly into the bottom, as far out from the bank as possible, the trap itself being kept close to land and covered merely by a few inches of water. The Beaver, attracted by the strong smelling substance, gives an approving slap of his tail, and starts off, if anywhere in the neighbourhood, to investigate the booty; and as he is leaving the water, gives a 'purchase,' so as to spring up the bank on the very place where the trap is concealed.[1] If the trap has been rightly set he will most likely be caught by his foot, but if the water over it be more than about four inches in depth, he will just as probably jump over it and escape. When caught, the animal tries to dive into the water again where it is deepest, and if he is unable to extricate himself by the summary process of biting off his own entangled limb, he is quickly drowned. Should the water in which the pole has been fastened be less than four or five feet deep, the amputation will very likely be effected and the trapper meet with disappointment.

Trapping is carried on from September till May, the remaining months of the year bringing to the Beaver brief security from the attacks of man. Occasionally spearing or shooting is employed for its capture, but trapping is the more usual method. The female produces her litter about the month of May. The young are termed 'kittens,'[2] and there are generally four of them brought forth at a birth. The male, as well as the mother, concerns himself in the care of the offspring, a duty prolonged even to the second year.

I have now mentioned the principal details connected with the habits of the Beaver, so far as the American variety is concerned, for though the Beaver of the Old World seems to be very similar (as already said), its much greater scarcity renders the work of observation more difficult. It remains to describe very briefly a few chief points in the structure of the Beaver.

The family of *Castoridæ*, or Beavers, contains but two genera, the Beaver and the Coypu. The latter animal is a native of South America, where it lives in situations similar

[1] R. Brown, *op. cit.* 367–8.

[2] The gambols of these little creatures are said to be exceedingly interesting. A hunter who was watching the movement of a number of 'kittens' with the intention of shooting some of them, was so moved by the likeness of their gestures to those of his own children at home, that he could not bring himself to hurt them.—*Vide Cassell's Nat. Hist.* vol. i. p. 275.

to the haunts of the Beaver, but it never forms dams. It is well distinguished by its smaller size and round tail. The skin of the Coypu is not unlike that of the Beaver, and has been applied to like purposes. The Beaver itself displays well its rodent character in the two powerful incisors (striped with bright orange enamel) which are placed on each of its jaws. There are four molar teeth on either side, made up of most complex folds. Five toes are found on each foot, and the hinder ones are webbed for swimming. The tail is flat and scaly, acting as a powerful assistant to the hind feet in the propulsion of the animal through the water. The body is about three feet in length, the tail nearly a foot more, and the weight of a full-grown specimen is over thirty pounds. The coat, of smooth, glossy hairs, is of a chestnut colour, the fine down which underlies it being somewhat greyish in shade. The flesh is often eaten in America, and is said to form a good dish when smoked and roasted. The tail, however, is only a delicacy to those of excellent digestion, being too oily and gristly for the palate of any but the most hardy trapper.

A very interesting monograph on the Beaver has recently been published.[1] It will do something to supply a long-felt want—reliable information on one of the most remarkable animals now existing.

The following new members were then elected :—

W. A. Smith,
W. Baillie,
G. Dakyns,
D. Pearce,
W. Oliphant,
J. Allen,
R. W. Wilson,
A. D. Greene,
J. Key,
H. J. Saunders,
C. C. Stevenson,
S. H. Leonard,
T. H. Warren.

Present, 36 members and visitors.

MEETING, June 10, 1870.

The President in the Chair.

Several ladies were present at this Meeting. The Rev. J. Greene read a paper on the genus 'Eupithecia' (Lep.). The following is a brief summary :—

[1] *The American Beaver and his Works*. by Lewis H. Morgan, Philadelphia.

After a few preliminary observations, Mr. Greene proceeded to remark that, up to the year 1860, great confusion existed both as to the arrangement and nomenclature of this interesting genus. This arose partly from the extreme difficulty of separating the species in the perfect state, and partly from the total neglect of them in the earlier stages of their existence. In the year above mentioned, the Rev. H. H. Crewe, M.A., a zealous and able Lepidopterist, commenced and carried on a thorough investigation of the larvæ. This was attended with the happiest results. Many new species were discovered—varieties merged—and others, which could not be distinguished in the perfect state, were determined and named, one of them being new to science. Having given a list of the British species (47) known up to that time, Mr. Greene entered into details of their economy, habits, food plants, localities in which they were found, &c. With the exception of two or three of the very common species, the insects in this genus were rarely taken in the perfect state. This latter expression was almost a misnomer, as, when captured on the wing, they were generally so much rubbed as to be undistinguishable. For this reason, he strongly impressed upon the entomological members the great advantage to be derived from searching for and rearing the *larvæ*, not only of this, but of all lepidopterous insects. The great majority of the larvæ of the genus Eupithecia fed upon the flowers, or within the seed vessels of various plants—generally very common ones, as Clematis vitalba, Traveller's Joy, Senecio Jacobeæ, Ragwort, Lychnis dioica, Catchfly, &c. These were easily obtained, by carefully examining the flowers, or beating them into an umbrella. The presence of a caterpillar within the seed vessel could generally be detected by the 'frass' ejected by the little inmate and collected round the hole by which it had entered. Those larvæ which fed on trees and shrubs were to be had by shaking or beating the boughs over an inverted umbrella. The *rearing* these caterpillars, when found, was a very simple process. Procure a box of almost any size or shape, with a closely-fitting lid covered with fine gauze. Cover the bottom of the box, to the depth of half-an-inch, with fine mould; on this place a little dry, loose moss, and then a handful or so of the flowers of the food plant. Fifteen or twenty caterpillars may be together in a box of moderate size. The food must be renewed every three or four days, great care being taken that none of the little caterpillars are thrown away. Mr. Greene spoke in highly favourable terms of the pleasure to be

derived from the study and pursuit of these little insects. The great number and variety of the species, the comparative abundance of many of them, the ease with which they were reared, and the extreme probability of discovering species as yet undetected in this country, all combined to render this one of the most interesting among the genera of Lepidoptera. At the same time, in this, as in all other pursuits, much patience, perseverance, and hard work were required to insure success. As an illustration of the last-named qualification, he mentioned the following incident:—'Some years since I arranged with an indefatigable brother entomologist in Dublin to go out one evening in October upon an ivy-hunting expedition; that is, to search for moths on the ivy bloom or flowers—a great attraction to insects of all orders. Upon meeting my friend at the appointed rendezvous, his appearance struck me with astonishment. He had on a large top coat, the pockets of which were stuffed with chip pill-boxes, and bulged out nearly a foot on each side. Across his chest was strapped a large bull's-eye lantern; in his left hand a bag net, with another small lantern fastened to it, the net itself being attached to a pole about eight feet long; and last, but not least, an eight-runged ladder was supported on his right shoulder. This latter was intended to be placed against trees or walls, where the ivy was beyond reach. Thus accoutred, we walked through the streets, accompanied by a small mob of excited and expectant boys, who evidently looked upon us as a couple of acrobats, regarding me, I suspect, as the exhibitor and my friend as the performer. However, we soon distanced them, and, having walked about two miles, reached our hunting ground. There, from about half-past six to nine, my companion worked away, conveying the ladder from tree to tree, and wall to wall, nimbly ascending it, boxing the moths, descending again, &c., and, finally shouldering it once more, returned home, leaving me, at any rate, thoroughly exhausted.'

Mr. Greene concluded his paper, which was listened to with much apparent interest, by urging upon his brother entomologists the adoption and practice of the motto, *viam aut inveniam, aut faciam*, which might be translated freely, 'Where there 's a will there 's a way.'

The following new members were declared to be elected:—

H. Niblett,	G. S. L'Estrange,
J. Stoddart,	A. E. Hay,
A. Warren,	W. Newmarch.

Present—43 members and visitors.

MEETING, JULY 1, 1870.

The PRESIDENT in the Chair.

The Rev. J. Greene, in the absence of the Secretary, read the minutes of the last Meeting.

The present Meeting was rendered especially worthy of note from the fact that Professor Church, of Cirencester, read to the Meeting a most interesting and valuable paper (illustrated by experiments) on 'Turacin,' an animal pigment containing Copper. He very kindly placed this paper at the disposal of the Committee, by whom the following extracts have been made:—

'*Origin of the present Enquiry.*—The stability of the colours which the feathers of birds display has been repeatedly proved. These colours are due either to what we may call the optical character of the surfaces of the web, or to the presence in it of definite colouring matters. These pigments may be opaque like enamel, or translucent and permeating the substance of the barbs; they have been as yet but very imperfectly studied. In a few instances only have they been actually separated from the structures containing them, while in no case have they been completely examined from a chemical point of view. So far as I can learn, we have no exact information as to the amount and the deportment, chemical constitutions and re-actions, of those substances, which M. Bogdanow,[1] some twelve years ago, succeeded in extracting from the feathers of many birds, and notably from the red feathers of *Calurus auriceps* and *Catinga cœrulea*. Before giving an outline of my own experiments in this direction, I will mention the particular circumstances which led to the prosecution of the present research.

'A few years ago, Mr. W. B. Tegetmeier pointed out to me a singular property of the red feathers of the bird called Touracou, or Plantain-eater. These feathers yield up a part of their colouring matter to pure water, a beautiful rose-coloured solution being thus obtained. Mr. Tegetmeier's attention had been drawn to this fact, and he at once perceived that it was worthy of fuller investigation than it had

[1] *Comp. Rend.*, xlv., p. 688; xlvi. p. 780.

already received. On further enquiry, I find that Mr. Ward, of Wigmore Street, had noticed the evanescence and solubility of the red tint in question many years ago, and that other observers, within the last few years, have even succeeded in staining pieces of paper with the red solution which these feathers yield. In order that it may be seen what was the position of the enquiry, when I commenced in 1866 my experiments on this subject, I may cite the authority of some private letters, which have been placed at my disposal, through the courtesy of Mr. Hugh Owen. These letters were written by Dr. Benjamin Hinde, principal medical officer on the military staff at Bathurst, on the Gambia. In one of his letters, dated May 1865, Dr. Hinde enclosed a piece of paper stained with the red pigment of a one-inch feather of the violet Plantain-eater (*Musophaga violacea*). He says that the moment soap touches the feathers the colour runs, but that it is difficult of extraction with pure water. But he adds, "the birds I sent home washed themselves nearly white in the water left for them to drink!" In a subsequent letter, Dr. Hinde gives some details concerning the different species of Plantain-eaters, and says, with reference to the feathers he had previously sent to England, "all the feathers were sent from the same bird, and grew in this house." This fact negatives any idea of artificial dye being present in the feathers, and is further referred to in the following memorandum by Mr. Hugh Owen:—"A pair of violet Plantain-eaters from the Gambia were sent over to a friend in Ireland by Dr. Hinde. The birds arrived in excellent condition, and were speedily provided with ample space and all appliances for cleanliness. For a while this splendid plumage, the deep crimson patch on the dark violet of the wing, excited continual admiration. After a day or two the crimson faded; in a few more, the colour changed to a pale and dirty grey. The disappointed owner wrote an account of this change to Bathurst, concluding, of course, that the natives had imposed on Dr. Hinde, by selling him a pair of painted birds; this, however, was impossible; there was no mistaking the peculiar and shield-shaped bill, or the legs of the *Musophaga*. Whatever change had taken place, the birds were genuine *Touracous*. Without delay, another bird was procured, so young as to be only partly fledged, the wings only in the pin-feathers. As soon as these were sufficiently grown, the experiment was repeated, and the colour found to be inconstant and capable of extraction." The data already given, and many others with which I have been sub-

sequently furnished, incontestably prove the normal presence, in some of the feathers of the Plantain-eater, of a red pigment soluble in water, and still more readily dissolved by soap. I may now give my own results as to the preparation, and physical and chemical properties of this new red animal pigment.

'*Occurrence of Turacin.*—The birds from which I have extracted this colouring matter generally go under the designation of Plantain-eaters, from their favourite food. It would appear that the native name for them is represented by the word *Touraco*; while the Dutch speak of one of the species as the Cape Lowry. These birds are entirely African. They belong to the order Scansores, and the family Musophagidæ; they are closely related to the Cuculidæ or Cuckoos. There are three genera of Touracos, *Musophaga*, *Corythaix*, and *Schizorhis*, altogether including eighteen species. The red pigment occurs in twelve only of these birds; namely, in both the known species of *Musophaga*, and in ten out of the eleven species of *Corythaix*. The eleventh species of *Corythaix*, in which it does not occur, is the Giant Touracou, which diverges in many other particulars from its brethren. The following is a list of the species, from which I have actually obtained the pigment; in the others, named above, I have merely recognised its presence by optical means:—

Musophaga violacea.
Corythaix (*Turacus*) *porphyreolopha.*
„ „ *erythrolopha.*
„ „ *albocristata.*

'The plumage of these birds does not present any great general brilliancy. The red pigment occurs in the primary and secondary pinion feathers, from twelve to fifteen of which have either a crimson blotch upon them, or are almost wholly coloured. I propose the name *Turacin* for the red pigment, which the Turacou (*Turacus*) contains. In order to extract this pigment, the plan finally adopted was as follows:—

'*Isolation of Turacin.*—The barbs, constituting the red part of the web, are stripped from the shaft of the feathers, placed in a beaker, and washed with ether and then with alcohol. This treatment removes the grease and adhering dirt very effectually. When the red barbs thus washed have been dried between folds of filter paper, they are placed in a cold, very dilute solution of pure caustic soda, a solution containing one part of soda in a thousand of distilled water

being quite strong enough. Ammonia, potash, or the carbonated alkalies may be used in lieu of caustic soda. The mass is stirred at intervals for fifteen minutes, or thereabouts; the crimson solution is poured off and pure water added; by successive treatment of the barbs with fresh portions of dilute alkali and pure water, the whole of the crimson pigment is obtained in solution, the residual barbs becoming white or pinky-grey. All the coloured liquors having been filtered and mixed, they are poured in a slender stream, with constant stirring, into dilute hydrochloric acid, made by mixing one part of the pure commercial acid with four parts of water. When the red precipitate of the pigment thus coagulated and rendered insoluble has settled, the supernatant liquid is decanted off, and the red matter thrown upon a wetted filter and washed with water. (A still better plan is, to employ a decanting siphon filter for the separation and washing of the precipitate.) The liquid comes through quite colourless, until there is no longer a trace of acid left in the pigment on the filter. When this occurs, the residue is washed off with water containing a few drops of acetic acid to the pint, and then syringed out of the filter into an evaporating basin and dried at a gentle heat. The dry pigment is next to be washed with a mixture of alcohol and ether, and once more dried. It is now perfectly pure, and yet unchanged, so far as I have examined it.

'*Properties of Turacin.*—Prepared as above described, Turacin occurs in scales, which have a deep violet purple colour by reflected light, and showing a crimson tint when seen in small fragments by transmitted light. Its powder is of a dull crimson tint. It has not been obtained in a crystalline form. It is very slightly soluble in pure water, giving a pale rose-pink solution. The presence of acids and salts renders water incapable of dissolving it. It is not soluble in pure alcohol or ether. In alkaline liquids it immediately dissolves, forming solutions, which show a bluer tint than the original pigment. In fact, Turacin is a very delicate test for the alkalies. For example, perfectly pure barium hydrate in solution does not dissolve Turacin; but let a minute trace of soda exist, as it often does, in the baryta solution, and then the liquid will become readily tinted if shaken up with a fragment of Turacin. Very strong solutions of the caustic alkalies dissolve the pigment, but at the same time it suffers a partial decomposition, evidenced by an odour resembling that of certain bases of the pyridine series, which it then evolves. Fuming nitric acid dissolves it with

a deep brown tint, destroying it; in oil of vitriol it is soluble, but, in all probability, with partial alteration. Turacin seems to have slightly acid properties; though it dissolves very freely in carbonated alkalies, caustic alkalies are still more effective. Turacin, by long exposure to air and moisture, or by continued ebullition with water or alkaline liquids, acquires a colour closely resembling that of chlorophyll.

'*Composition of Turacin.*—The volatile constituents of Turacin are carbon, hydrogen, nitrogen, and oxygen, in what proportions I shall presently state. It contains no sulphur. The ash, or non-volatile constituents of the new pigment have also been submitted to a careful examination. Turacin may be dried at 100° without change; but at a considerably higher temperature its surface colour alters, becoming bluish and then a dull green. Afterwards it shows some symptoms of fusion, giving off a violet vapour resembling that of iodine; it finally burns away, leaving a greyish black ash.

'The close resemblance of Turacin to Cruorin induced me to test at once—in the ash of the new colouring matter—for iron, the characteristic metallic constituent of the pigment of the blood, and of its derivatives. The ash of Turacin was dissolved in nitric acid, excess of sodic acetate added, and then potassic ferrocyanide. Much to my surprise, instead of the deep blue *ferric* ferrocyanide, a copious purple brown precipitate of *cupric* ferrocyanide made its appearance. Not only was copper present, but there was so much of it, that it could be detected by its spectrum, when the ash of a few red barbs of the original feathers was moistened with strong hydrochloric acid and exposed on a platinum wire to the flame of a Bünsen burner.

'This detection of copper in the colouring matter was so extraordinary, that it became necessary to sift the matter thoroughly. The idea that a preservative solution containing copper had been used in dressing the skins of the bird suggested itself; but this notion was soon proved untenable; for there is no copper in any part of the skin save in the red feathers, and in these feathers themselves the presence of copper is strictly confined to the red barbs. Even barbs that are partly red and partly black contain no copper in their black parts, and abundance in those that are red. Moreover, as acids do not wash out the copper from the feathers, and the most severe chemical treatment, short of actual destruction of the pigment itself, does not remove it from the prepared and pure Turacin, it is evident that this metal, copper, is an integral constituent of the substance

under investigation. Some idea may be formed of the intimate union subsisting between the copper and the other constituent elements of the colouring matter, from the observation, that Turacin dissolved in oil of vitriol, and re-precipitated by excess of sodium acetate, suffers by this treatment no loss of copper.

'The different parts of eighty-seven red feathers of *Corythaix albocristata* have been carefully examined. From the red barbs of these a considerable quantity of Turacin was prepared, while their shafts were submitted to special dissection. The clear, horny parts, or quills proper, at the base of each feather, were cut off and separately incinerated; so also were the upper parts or shafts of the eighty-seven feathers, and in like manner, the membranes found in the quills. There was no copper in the ash of the eighty-seven quills and none in that of the membranes; but a very minute trace was recognised in the ash of the shafts. There is therefore no possibility of any mistake having occurred as to the copper present in the red parts of the feathers of the Touracous. It cannot have been introduced in any preservative solution, for it would then be found in the black parts of the web, as well as in the red; it cannot be an artificial dye, for birds bred in captivity acquire the cupreous pigment naturally;[1] it cannot be an accidental and unnecessary constituent of the red colouring matter; for not only is it impossible to remove this metal from the pigment, but the proportion of copper present in the Turacin obtained from different species of Plantain-eaters remains constant

. . . . . .

'Notwithstanding the diversity of origin and certain changes in the mode of preparation, the analytical results have been remarkably concordant.

'*Affinities of Turacin.*—In its colour, in its absorption-spectrum, and in some of its other characters, Turacin corresponds closely with the scarlet Cruorin of blood, yet it contains no iron, or, at most, an inappreciable trace of this metal. Iron, however, exists to the extent of between six and seven per cent. in hæmatin, the chief derived colouring matter obtained from the blood, and is doubtless a constituent of the original Cruorin; yet if, in Turacin, the iron of Cruorin is replaced by copper, there are other and wider differences of composition and deportment between the two pigments, which prevent us from regarding Turacin as a

[1] Private contribution from J. J. Monteiro, Esq., Dec. 10, 1867.

Copper Cruorin. Moreover, Turacin does not seem to occur in corpuscles, but to be homogeneously distributed in the barbs, barbules, and crochets of the red feathers in which it occurs.

'Turacin seems to characterise the closely-allied genera *Musophaga* and *Corythaix*. These birds, though with the other Touracous distinctive of the African Ornis, are not common; and in consequence, the supply of Turacin for experimental purposes is very limited. I have not detected it in any of the other red-plumaged birds, which I have examined. The quantity of Turacin in a single bird is small. It is most abundant at the pairing season, and the bridal plumage of a *Corythaix albocristata* generally yields from two to three grains of the pigment. One bird may then contain in the colouring matter of its wings nearly ·2 of a grain of metallic copper.

'Turacin is the first animal or vegetable pigment containing copper as an essential constituent, which has hitherto been isolated; yet traces of copper have been repeatedly found in both animals and plants. It was detected by Harlen in the blood of certain Ascidia and Cephalopoda. It occurs in *Limulus cyclops*, *Cancer pagurus*, *Acanthias zeus*, and *Conger vulgaris*, its quantity being in inverse ratio to the quantity of iron present. The blood of *Helix pomatia* contains much copper, the part of the ash insoluble in water yielding 2·57 per cent. Many chemists have detected minute traces of copper in human blood; and twenty years ago Deschamps arrived at the conclusion, that it is normally contained in the blood of man and animals. Odling and Dupré have indeed, subsequently, detected copper in flour, straw, hay, meat, cheese and other articles of food. It has been supposed that the copper detected in some of these substances has been introduced in the course of analysis by the use of brass burners, and retort rings; but these in most cases are a purely imaginary source of error. It is not difficult to perceive, whence the Touracous derive the copper which their feathers contain, and I have actually succeeded in obtaining unmistakeable indications of copper from the ash of three fruits of a plantain, the common Musa sapientum. There is, of course, still room for experiment and further observation in this direction. Researches as to the source of copper—whence vegetables assimilate it—the occurrence of ores of copper near the habitats of the Touracous—and its detection in the articles of food supplied to these birds, when kept in captivity, will doubtless lead to interesting results. The

whole subject of the occurrence of copper in animal products is fraught with physiological as well as chemical interest.'

A special vote of thanks was unanimously passed to Professor Church for the above paper.

T. H. Warren then read a paper on 'Dragon Flies.' Having alluded to the erroneous ideas entertained by the unscientific, as to their true nature, he drew attention to the great voracity, both of the larva and imago, and also to the extraordinary power possessed by the perfect insect, of maintaining a rapid and sustained flight—illustrating this latter peculiarity by a quotation from Professor Owen. Having briefly touched upon the Order (Neuroptera) to which Dragon Flies belong, he explained at some length their transformations, structure and habits as exhibited in the various stages of their existence, and concluded his paper with the expression of a hope that some of his hearers might be induced to enter upon the study of so beautiful and interesting a class of insects, which, nevertheless, had been comparatively neglected.

The following were elected as Honorary Members:—

Rev. H. C. Watson, M.A., F.R.A.S.
C. J. Peile, Esq., B.A.

Present, 70 members and visitors.

MEETING, July 2, 1870.

This was a meeting specially convened for the purpose of considering the details of an excursion to Brockley Combe. After considerable discussion, the following members were appointed Stewards of the Excursion and to make all necessary arrangements:—

	Representing
Rev. J. Greene,	*Sc. Soc. Committee.*
Mr. Barrington Ward,	
T. H. Warren,	
W. Claxton,	
J. E. Pearson,	
A. W. Brodie,	*School House.*
R. F. Brunskill,	*Brown's do.*
W. E. Evill,	*Dakyns' do.*
H. Proctor,	*Harris' do.*
C. T. Blanshard,	*Town.*
M. J. Ward,	*Junior School.*

The excursion took place on Saturday, July 9th, and the President, Mr. Barrington Ward, kindly drew up a brief notice of it:—'The members of the Society, seventy in number, had their annual pic-nic to-day. They left Clifton College shortly before noon, in several Drags and Omnibuses, and drove to the beautiful locality which had been selected for the purpose—viz., Brockley Combe. Unfortunately the day proved exceedingly wet, yet not sufficiently so as to damp the ardour of the party, all of whom thoroughly enjoyed themselves. A farmer (Mr. Thatcher of Downside House), kindly lent a large barn, which, by the efforts of the stewards and others, was speedily converted into an impromptu dining-room. Here the Society remained about two hours, and enjoyed the excellent dinner, which the members had jointly contributed. Some songs followed, and as the rain began to clear away, the party dispersed to view as far as possible the neighbourhood. All reassembled about six o'clock, and the operation of 'packing up' was soon accomplished. Then the rain began to fall once more, and poured down steadily all the way homewards. Clifton was reached shortly before 8 P.M. Nearly everyone had a good wetting, yet no serious results followed. Alas! the day we chose for our excursion was the only wet one in the whole term.' *Absit omen!*

MEETING, July 14, 1870.

This was the fourth and last Ordinary meeting of the Term. The Rev. J. Greene, Treasurer, in the Chair.

The minutes of the last meeting having been read and approved, H. Proctor read an interesting Paper—unfortunately lost—upon the 'Oak,' which was received with much applause. On the motion of the President, Mr. Barrington Ward, a vote of thanks was unanimously passed to H. Proctor for his paper; and as he was shortly to leave the College for Oxford, the best wishes of the Society were expressed for his success there.

A. Cruttwell then read a Paper on the 'Outlines of Geology.' At the conclusion of this paper, the Society proceeded

to the election of its officers for the ensuing Term. The following were chosen :—

Mr. Barrington Ward, *President.*
Rev. J. Greene, *Treasurer.*
J. Stone,
R. F. Brunskill,
T. H. Warren,
W. Claxton, } *Committee.*

At this Meeting also, Mr. Barrington Ward was requested to prepare an Address to Dr. Debus, on his retirement from the office of President, and removal from the College.

Present, 52 members and visitors.

MEETING, Sept. 30, 1870.

Among the members and visitors (47) at this, the opening meeting of the Term, were the Head-Master (the Rev. J. Percival), and the Rev. A. Butler. The President, Mr. Barrington Ward, delivered an Inaugural Address, principally in explanation and defence of the 'Darwinian Theory.' The members present having declined to avail themselves of an invitation to state their opinions on the above subject, the Rev. J. Greene expressed a hope that Mr. Percival would make a few observations. In compliance with this request, Mr. Percival spoke at some length, of the warm interest he took in the Society and its objects, and heartily thanked the President for the energetic way in which he had entered into its plans and direction.

The President, in reply, proposed a vote of thanks to the Head-Master for his splendid gift to the College.[1] Carried by acclamation.

Mr. Percival, briefly responded, and at the conclusion of his remarks, observed that he thought it only right that a vote of thanks should be proposed to the Rev. J. Greene, for his unwearied interest in the Society. Mr. Greene having acknowledged the compliment, the Meeting adjourned.

[1] This refers to the gift, by the Head Master, of the Building for the Library and Museum.

MEETING, Oct. 7, 1870.

The President read a communication from the Head Master of Winchester College, offering to exchange 'Transactions.' Also an 'Address to Dr. Debus,' and his reply.

After the reading of the above letters, the President introduced G. F. Rodwell, Esq., F.R.A.S., F.C.S., who read the following Paper:—

THE LIFE AND WRITINGS OF ROBERT FLUDD.[1]

The first half of the seventeenth century was rendered so exceptionally brilliant by the labours of Francis Bacon and of Galileo, that many lesser names have almost passed from the memory of mankind. This must ever be the case in an age distinguished by the presence of men who dignify and illumine, not alone their own period, but all time. In one sense it was the misfortune of Leo Baptista Alberti that he was the contemporary of Michael Angelo and Leonardo da Vinci; and similarly it was the misfortune of Robert Fludd that he was the contemporary of Bacon and Galileo. Fludd lived in an age that was altogether stupendous; it abounded in intellectual giants, and men, who would have been the glory of any ordinary age of mental activity, were now almost unnoticed. A profound change had taken place in the character and attitude of human thought—a change which some of the martyrs of the preceding century had hastened, and almost brought to a climax. We must not forget that the world had been somewhat prepared for this change: Copernicus and Regiomontanus, Jordano Bruno, Marius Nizolius, and many others had swerved far from the established and orthodox course of philosophy; in other directions the power of the Church had been lessened by Savonarola and Luther, and a host of reformers; and the invention of printing had done much to induce a freedom of thought unknown for many previous centuries. Hierarchical influence had long been on the wane. It has been remarked that the long pontificate of Urban VIII. was a period of transition from strength to weakness; but I would rather call it a transition from an already commenced weakness to absolute feebleness. The Church had been attacked on many sides at once, and the downfall of scholasticism was not least among

[1] Portions of this essay have been printed elsewhere, but it has not appeared before in this form in which it was read to the Society.

the causes which contributed to its discomfiture. Ideas which had been revolving in the minds of many generations, and had been uttered secretly and in peril, were now made known to the world at large, as the power which had restrained them loosed its grasp. The musings of many a bygone age were proclaimed and made manifest in this age.

The philosophy of Robert Fludd is not typical of the period in which he lived; it rather typifies and personifies the thought of times long past. Although Fludd was not a very staunch conservative, he was far too conservative for that age of progress; in a very few respects he was ahead of his contemporaries; in some he kept pace with them, but in many he lagged far behind them. He was not one of the great thinkers of his day, but he was a man of the most varied learning, and unwearied in his labours. He was called the *Searcher*, in that he was ever prying into the secrets of Nature, and he was accounted 'strangely profound in obscure matters.' Brücker ('Institutiones Historiæ Philosophicæ') says of him: 'Cum imaginationis vehementia fureret, et paracelsica, cabbalistica, magica, vetera, nova, in unum confunderet, quibus tamen haud pauca erudita, et a naturali experientia desumta admiscuit.'

Robert Fludd was born at Milgate, in Kent, in 1574, and was the son of Sir Thomas Fludd, Treasurer of War to Queen Elizabeth. The Latin writers of the period frequently designate him *Robertus de Fluctibus*, and his philosophy, *Philosophia Fluddana*; his name is sometimes written *Flud*, less seldom *Floud*, and rarely *Flood*. In a single instance he published a work under the name of Rudolf Otreb, which is an anagram of his name. At the age of seventeen Fludd became a commoner of St. John's College, Oxford, where he devoted himself to the usual studies, and to medicine, and after taking the degrees in arts, he went abroad for six years, and travelled through France, Spain, Italy, and Germany. In 1605 he took his M.D. degree, and became Fellow of the College of Physicians. Shortly afterwards he commenced practice in London, where he appears to have attained considerable success in his profession. His numerous works were published between 1616 and 1633, and, with a single exception, were printed abroad and in Latin, the reason for which will presently appear. He died on September 8, 1637, at his house in Coleman Street, and was buried in Bearsted church, near the place of his birth. Such appear to be the only facts which are known of the life of Robert Fludd. The few authors who mention him speak of his

works rather than of his life, and they sometimes make the most discordant statements. Thus Wood (*Athenæ Oxonienses*), after accusing him of profanity, adds, 'None hath exceeded more, even to the height of blasphemy;' while Webster calls him 'one of the most Christian philosophers that ever writ.' Fuller (*Worthies of England*) summarises his account of Fludd's numerous folios in the single sentence, 'His books, written in Latine, are great, many, and mystical. . . . The truth is,' he adds, by way of apologising for knowing nothing of their contents, 'here at home his books are beheld not so good as crystal, which (some say) are prized as precious pearls beyond the seas.'

Let us now glance rapidly at the main facts of the philosophy of Fludd, and afterwards consider one or other of his works in detail.

According to Fludd, God is the beginning, the end, and the summation of all things. The act of Creation is the separation of the active principle (*Voluntas Divina*), represented by light, from the passive principle (*Noluntas Divina*), represented by darkness. By the interaction of these principles everything is produced. The universe is composed of four worlds: the archetypal world, in which the Deity specially manifests Himself; the angelic, inhabited by angels, who are the direct communicators of the Divine will; the stellar, containing the planets and all the heavenly bodies; and, lastly, the earth, and the creatures which inhabit it. These four worlds may be reduced to three—viz., the archetypal world, the macrocosm, and the microcosm; or, God, the world, man. The archetypal world is formed of three manifestations of the Deity, represented by the Three Persons of the Trinity. God, in this threefold character, presents the image of a circle (which has ever been the symbol of perfection), 'Cujus centrum est in omnibus, circumferentia extra omnibus.' The greater world, or macrocosm (*μακρὸς κόσμος*) is an emanation from God, and is divided into three regions, corresponding to the Three Persons of the Trinity—viz. the empyreal region, occupied by angels; the ethereal region, or heaven of fixed stars; and the elementary region, occupied by the earth. The lesser world, or microcosm (*μικρὸς κόσμος*) is man, because he presents a counterpart of all the parts of the macrocosm. The head corresponds to the empyreal heaven, the breast to the ethereal heaven, and the stomach to the elementary region. The different parts of the macrocosm have representatives in the microcosm, and these correspond by the law of sympathy, and necessarily are

influenced the one by the other. This system of the world was revealed, according to Fludd, by the Deity to the first man, and by him transmitted to the patriarchs and Moses. The three great philosophers of antiquity—Pythagoras, Plato, and Hermes Trismegistus—adopted it from the Bible, but made many alterations in reproducing it. Aristotle, on the other hand, was not acquainted with the sacred writings: his books are full of follies and errors, and he has been the cause of infinite heresies. It can well be understood that these assertions were not allowed to remain unattacked, and Fludd numbered amongst his opponents Kepler, Mersennus, and Gassendus, notably the latter, whose 'Exercitatio in Fluddanam Philosophiam' was replied to in considerable detail by Fludd.

It will be noticed above that Fludd speaks of Hermes Trismegistus as one of the three greatest philosophers of antiquity; and from the frequency with which he quotes him, I should be inclined to think that he is considered the greatest of the three. Hermes Trismegistus is often confounded with the Egyptian God Thoth, the inventor of numbers and letters, but they are distinct. According to Clemens Alexandrinus, Hermes was an Egyptian, and the author of forty-two books, which his countrymen treated with the most profound respect, and were wont to carry in their religious processions. Thirty-six of these (including four on astrology) contained all the philosophy of Egypt; while the remaining six treated of medicine, anatomy, and the cure of diseases. In the temple of Hermes at Pselcis, he is represented with a staff having a snake turned round it; from which emblem the Caduceus of Mercury may have been derived. Some make Hermes a priest and philosopher who lived a little after the time of Moses; others a contemporary of Osiris. However all this may be, it is certain that several books appeared during the middle ages, which claimed Hermes Trismegistus as their author; and it is equally certain that they were written by Neo-Platonists and Gnostics during the early centuries of the Christian era. Fludd has drawn largely upon the supposed works of Hermes; his cosmogony is nearly the same as that of Hermes, and much of the supernatural machinery which he introduces is derived from the same source. From this cause, the philosophy of Fludd is strongly tinctured with Neo-Platonism.

I am inclined to regard, as Fludd's principal work, the 'Historia Macrocosmi,' which was published at Oppenheim in 1617 and 1618, and which we will consider somewhat in

detail. It is entitled *Utriusque Cosmi majoris scilicet et minoris Metaphysica, Physica, atque Technica Historia*, and is in the form of a closely-printed folio, full of copper plates. It is dedicated to God, as was not uncommon at a somewhat earlier period—'Deo optimo maximo, Creatori meo, incomprehensibili, sit gloria, laus, honor, benedictio, et victoria triumphalis, in secula seculorum. Amen.' Then follows a dedication to James I., in language which must have been rather too laudatory even for that vainest of monarchs. After this, we have one of the large emblematical designs in which mystical writers took so much delight; a design in which the earth forms the centre of a circle, while cherubim and all the host of heaven form the circumference. Immediately around the earth we observe three circles, within which appear respectively typical products of the animal, vegetable, and mineral kingdoms, as adapted by art to the uses of mankind; a fourth circle contains types of the liberal arts, a fifth of the mineral kingdom, a sixth of the vegetable kingdom, a seventh of the animal kingdom. The eighth circle represents the sphere of air, the ninth that of fire, the tenth to the sixteenth the circles of the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. The seventeenth circle encloses a quantity of stars, and is called *Cœlum Stellatum*, and the three outer circles are fringed with tongues of flame, and contain cherubim and seraphim. At the limit of the outermost circle, the hand of God is seen projecting from a cloud, and leading by a chain Nature, personated by a human form bearing the sun and moon and girt with stars, while from her hand depends a chain by which she leads an ape seated upon the earth. The ape personates art; for Fludd elsewhere says, 'Natura, et ejus simia quam artem appellamus.' It can be well understood in reference to this emblematical figure, that although the world is not more than an inch in diameter, the whole figure terminated by the circle of the cherubim extends over more than a foot. It is, in good truth, a wonderful mass of uncouth symbolism, and many such are found in the writings of Fludd, and of the mystics of his school. After the symbolic design, the work begins in good earnest with an account of the creation, and of the construction of the macrocosm; the nature of the empyrean, and the form of the elements. The third book (or 'chapter,' as we should call it now-a-days), 'De Musica Mundana,' is essentially Pythagorean in character. In it Fludd endeavours to prove that unity and rhythm prevail in all things, and we

may be sure a chapter on the music of the spheres is introduced.

Book IV. treats 'of the Creatures of the Empyrean,' and in this the nature of demons is fully discussed. In the paragraph relating to bad demons, we find such sentences as the following:—'Accusing and culminating demons occupy the eighth mansion, whose prince is called Ashtaroth, who, active and filled with joy, exaggerates our sins before God.' It will give us some idea of the extent of reading and information possessed by Fludd if I mention the various authors quoted by him in the sixteen pages of this fourth book:—They are Plato, Proclus, Dionysius, Possidonius, Heraclitus, Hippocrates, Hipparchus, Zeno, Jamblichus, SS. Augustine and Basil, Hermes Trismegistus, S. John, Trithemus, Aristotle, Xenocrates, Asclepiades, Democrates, Parmenides, Epicurus, Empedocles, Ericrates, Theophrastus, Marcus Manilius, Boëthius, Virgil, SS. Athanasius and Bernard, Psellus, Agricola, Isidorus, Freigius, S. Gregory, Olaus Magnus, Apuleius, S. Paul, Critias, Dinarchus, Tertullian, S. Peter, Porphyry, Seneca, Aristoxenus, Remigius, and Avicenna Surely this indicates an extent of reading which but few men of the day could have possessed.

Book V. treats 'of the Creatures of the Ethereal Heaven,' and we find herein Fludd's ideas regarding the origin of the sun, and the cause of the 'circular movement of the heavens,' as the apparent motion of the sun was then called. He also devotes some space to the refutation of the Copernican theory, which had a few years before been adopted by Gilbert of Colchester (of 'De Magnete' fame), to his honour. The remarks which follow in the next chapters about thunder and lightning, and meteors, appear to be taken from Lucretius and Pliny, and certainly lack any originality. The second part of the 'Historia' is devoted to a technical history of the Macrocosm, which is considered in the following order: 'of Universal Arithmetic,' 153 pages; 'of Music,' 100 pp.; 'of Geometry,' 31 pp.; 'of Optics,' 23 pp.; 'of the Art of Drawing,' 24 pp.; 'of the Military Art,' 89 pp.; 'of Motion,' 68 pp. (containing an account of various machines and pieces of mechanism, in the designing of which Fludd was said to be proficient); 'of Time,' 25 pp.; 'of Cosmography,' 28 pp.; 'of Astrology,' 156 pp.; and 'of Geomancy,' 73 pp. Note the significancy of the extent of the two last-named subjects. Taking the whole work of more than 900 folio pages, we find nearly *one-sixth* of the space given to astrology, or, taking together the astrology and geomancy (divination by figures

drawn on the earth, γῆ μαντεῖα), nearly *one-fourth* of the work is thus occupied. In round numbers, one-fifth of the work is devoted to the physical and metaphysical history of the Macrocosm, and four-fifths to its technical history; and of the latter branch, about one-ninth of the work is occupied by music, one-eleventh by military matters, about one-sixth by arithmetic, and one-fortieth by optics.

The other writings of Fludd, although numerous, need occupy but little of our attention. In 1619 the complement of the 'Historia Macrocosmi' was published at Oppenheim, under the title of 'Tomus Secundus de supernaturali, naturali, præternaturali, et contranaturali microcosmi historia in tractatus tres distributa.' In this work we find at the commencement an *oratio gratulabunda* of considerable length addressed to the Deity, and much occupied by quotations from the Psalms and from Hermes Trismegistus; it rises here and there to a certain tone approaching sublimity. In 1624 Fludd published a bulky work entitled 'Philosophia Sacra et vere Christiana seu Meteorologica Cosmica,' which does not, however, differ in general character from the work described above, and developes further the idea of the influence of supramundane upon mundane affairs. In 1623 he published his 'Anatomiæ Amphitheatrum effigie triplici,' in the form of a folio of 285 closely-printed pages. It is full of copper plates of various parts of the human body, dissected and otherwise; and the drawings are certainly as good as any similar ones which I have seen of the same period. I would specially draw the attention of those who may be interested in this subject to the ten figures representing the dissection of the larynx (p. 145), also to the plates which illustrate the anatomy of the brain. In this day astrology was so intimately associated with the affairs of life that we are not surprised to find, at the end of the ordinary anatomical description of the various parts, a list of the planets which influence those organs, and the conditions under which they are influenced for good or for evil. There is also a chapter entitled 'De Anatomia Mystica.'

Among the last works which Fludd published were three large folios, entitled 'Medicina Catholica, seu mysticum artis medicandi sacrarium.' These were published in Frankfort, in 1629, 1630, and 1631, and the motto of the book is *Non est vivere sed valere, vita.* In this work, more, perhaps, than in any other, does Fludd employ hieroglyphics, such as the astrologers delighted in; we not unfrequently find sentences which consist of two-thirds symbols and one-third

words, and the latter are often much contracted. At the beginning of the first volume of the 'Medicina Catholica' (which is dedicated to the then Archbishop of Canterbury), there is another of the emblematical figures of which Fludd was so fond. In it a healthy man ('Homo sanus') is seen kneeling in the midst of a kind of citadel, the four corners of which are guarded by Raphael, Uriel, Michael, and Gabriel, each with a drawn sword. From the north is let loose upon him the demon Mahazael, riding upon a gigantic frog, and poising an arrow aloft in his hand; from the south appears Azazel, a demon riding upon a dragon; from the east, Sammaël (the messenger of death), astride upon a winged dragon, and holding a torch in his hands; while from the west comes Azael, riding upon a dolphin. The first volume contains a great collection of medical facts; but, as we pass on to the second and third, the matter becomes weaker and weaker, until it culminates in the most arrant puerility. In the chapter 'De nomandia sive onomantia,' rules are given in great detail for finding out the priority of death in the case of two relations, and some of these rules are as arbitrary as, and somewhat of the nature of, the divination we practise when we count our cherry-stones, and say, 'This year, next year, sometime, never.' Again, what shall we say to ninety-three pages devoted to divination, by feeling the pulse under different planetary conditions. But the crowning point of folly and superstition remains: will it be credited that any man, much less a man of Fludd's capability, could devote 180 folio pages to '*Ouromantia* hoc est divinatio per—*οὖρον*?' Imagine a vast system of vaticination based upon the observation of *οὖρον*, under various stellar and other conditions. Can anything be more infinitely pitiful than this? Did any act attributed to the Laputan philosophers exceed this for folly? We can but regret that the infinite care and ingenuity exercised in these pursuits could not have been legitimately applied. The same minute habits of observation, which in one age could only produce a treatise on Ouromantia, might in a later age have produced an elaborate treatise on some refined manipulation. Nature piped unto the men of that day as she pipes unto us, but their minds were not attuned to the sound; hence they danced not. We all know how many years elapsed before we rightly appreciated that joyous harmony.

Fludd wrote a few other works of minor importance, among them a 'Clavis philosophicæ et alchymiæ,' a treatise addressed to the Rosicrucians (of which fraternity he was a

zealous and prominent member), and an answer to the attacks of Gassendus and Mersennus. Almost the last work which he wrote was an answer to the attack of a clergyman named Foster, and this (which was the only work he published in England and in English) merits a short notice, as peculiarly illustrative of the times. A certain William Foster, 'M.A., and parson of Hedgeley, in the county of Buckingham,' published a brochure of fifty-six pages, in 1631, entitled 'Hoplocrisma spongus; or, a sponge to wipe away the weapon-salve. A treatise wherein is proved that the cure late taken up amongst us, by applying the salve to the weapon, is magicall and unlawful.' First, as to the *weapon-salve*, it appears that Paracelsus invented a certain unguent, which he asserted would cure all wounds arising from violence by being applied to the weapon which had caused the wound (or to its facsimile in wood), under certain stringent conditions. The unguent was to be compounded of moss from the skull of an unburied man, 'mummy,' man's blood, and oil, while some recommended the introduction of 'the dryed brain of a wilde bore.' The most minute directions were given for applying this to the weapon, and a slight carelessness might as easily cause the death of the patient as his cure. Thus it was said, 'Beware that the weapon fall not downe, nor the winde blow upon it in a cold place, for it will force the patient to madness.' Many writers had written strongly in favour of this cure, among them Crollius, Baptista Porta, Cardanus, Burgravius, Coclinius, and notably Robert Fludd, a physician by profession, be it remembered. Lord Bacon alludes to the alleged cure ('Sylva Sylvarum,' cent. 10, par. 998), and adds, 'Though myself, as yet, am not fully inclined to believe it.' Parson Foster is most bitter against the whole thing, and declares that it is the work of the devil. He is specially virulent against Fludd, as the most recent advocate of the cure, and his brochure is principally directed at him. In the preface Foster says: 'I dare call sin, sin in whomsoever. If Jesabell be painted, with Jehu I will not have peace with her to commend her, though a Queene. If Herod be incestuous, with the Baptist I'll not sooth him, though a King. If Simon Magus be a sorcerer I feare not his divell, with S. Peter I'll rouze him though a witch. Shall anyone for my boldnesse think to sit upon my skirts? Let those knowe I esteeme myself *infra invidiam*. I cannot have lesse in the Church, unlesse nothing. And if they shall endeavour to keepe me still low, let them knowe I look for no good from

them that envie my endeavours to do good.' Fludd, at first, took no notice of the attack, deeming Foster, as he tells us, not worth answering; but finding one morning that Foster had caused the title-page of the 'Hoplocrisma Spongus' to be nailed to each of his door-posts, he was so incensed thereby, that he forthwith brought out a brochure of 212 pages in reply. It is entitled, 'The squeezing of Parson Foster's sponge, ordained by him for the wiping away of the weapon-salve. Wherein the sponge-bearer's immodest carriage and behaviour towards his brethren is detected; the bitter flames of his slanderous reports are by the sharpe vineger of truth corrected and quite extinguished; and, lastly, the vertuous validity of the sponge in wiping away of the weapon-salve is crushed out and thus abolished.' On the title-page Fludd pointedly introduces a verse from the 92nd Psalm, concerning the fall of the wicked man, and also the somewhat cutting remark, 'Opera Dei, vir brutus et stultus non intelligit.' It is to be confessed, however, that he was a good deal provoked. Foster, after quoting several men who had advocated the weapon-salve, and indirectly introducing Fludd amongst them, says: 'I wonder at nothing more than that Beelzebub was not in the number;' to which Fludd replies, 'A singular diabolical conceit. . . . Marry, I will tell him why: if it had been true that the use of the weapon-salve is witchcraft, and the users thereof witches and conjurers (as he boldly saith), how, I pray you, should Beelzebub be missing from our company? . . . And this is the reason that Mr. Foster and his like have failed to find Beelzebub or the Devil in this number; forasmuch as he is nearer to them than they are aware of.' 'Dr. Fludd,' says Foster, 'hath been written against for a magician, and I suppose this to be one cause why he hath printed his bookes beyond the seas;' to which Fludd replies, 'I sent them beyond the seas because our home-borne printers demanded of me five hundred pounds to print the first volume, and to find the cuts in copper; but beyond the seas it was printed at no cost of mine, and that as I would wish; and I had sixteen copies sent me over, with forty pounds in gold as an unexpected gratuity for it. How now, Master Foster, have I not made you a lawful answer?' The book here alluded to is the 'Historia Macrocosmi,' which has been discussed at some length above. It is not surprising that five hundred pounds was demanded for printing the volume, when we observe the very large number of elaborate copper plates. We cannot wonder that Fludd published his works abroad

after the above statement; and it also indicates to us that they were far more prized on the Continent than in his own country. After vindicating himself, and disavowing all connection with magic and necromancy, Fludd attacks Foster's statements about other matters. 'I will proceed now,' he says, 'to the greatest assault, wherein his sponge rubbeth very hard against my text, but prevaileth no more than they which go about to wash away the colour of a black-moore.' He then enters into an elaborate statement to prove that 'devils have aëry bodies allotted to them in their creation,' which Foster had denied. And thus the foolish controversy is carried on to the end. It is surprising to observe what an amount of erudition is brought to bear upon it from both sides; an assertion is rarely made without a quotation to back it up, Foster preferring the Fathers of the Church, notably SS. Augustine and Jerome, while Fludd goes back to the ancient Greeks and to Hermes Trismegistus. They both quote the Scriptures profusely—Foster because he is a clergyman, Fludd because he knows that arguments drawn from that source will most prevail with a Churchman. It may be here remarked that Fludd invariably shows a most intimate acquaintance with the Bible, which from beginning to end of his numerous works he never fails to quote when an opportunity for so doing arises.

It is, of course, impossible here to attempt any detailed analysis of the authorship of the prominent tenets of Fludd's philosophy. We have seen from the list of names given above, how great and varied were the sources whence he drew his opinions. His cosmogony is closely related to that described as Chaldæan, in the writings of Psellus, Sextus Empiricus, Porphyry, Jamblichus, and Proclus, and in the works of the same period which bear the name of Hermes Trismegistus. His astrology is mainly compiled from the Middle Age works on the subject, which are themselves based on Arabic works: the various views of the Rosicrucians also find expression. His *iatromathematics* is obviously taken from one of the works attributed to Hermes Trismegistus, under whose name was published, in 1532, a treatise entitled '*Ἰατρομαθηματικὰ ἢ παρὰ κατακλίσεως νοσούντων προγνωστικὰ ἐκ τῆς μαθηματικῆς ἐπιστημης.*' His anatomy is taken mainly from Vesalius, and his medicine from Paracelsus and his followers, but it is probable that a careful and unwearied observer like Fludd added a good deal of new matter in this direction, since it was the subject of his profession. His geometry comes mainly from Euclid, music from Guido of

Arezzo, optics apparently chiefly from Baptista Porta, but, undoubtedly, also from Vitello, and from various Arabic sources. Fludd was neither a Copernican nor an Aristotelian; nor does he appear to have been impressed by any of the discoveries which were being made round him by Gilbert and Galileo, or by the writings of Bacon. As to his natural science, he not unfrequently shows considerable aptitude for such studies, and great minuteness of observation. Of the old experiment, in which a candle is burned in a closed vessel standing over water, which latter, on the extinction of the flame, ascends somewhat into the vessel, he says, '*Aer enim nutrit ignem et nutriendo consumitur*,' but he denied the possibility of a vacuum. Again, in the 'Anatomiæ Amphitheatrum,' we find a chapter entitled 'De anatomia sanguinis humani chimia artificiali dissecti;' this he recommends to be done by submitting the blood to a gradually increasing degree of heat in a retort, and collecting the products at various stages, in other words, a 'fractional distillation,' of necessity rough, for thermometers were then unknown. As to Fludd's astrology, perhaps the most rational thing to which he attempts to apply it is the prognostication of tempests, but the casting of horoscopes is a favourite subject, and one part treats of the discovery of a thief. 'The truth of this portion of the art,' he says, 'is not alone supplied by others, for I also have confirmed it by practice and experience;' he then tells us how to discover who the thief is, 'if the Lord of the Sixth House is found in the Second House, or in company with the Lord of the Second House, the thief is one of the family, either parent, or brother, or sister;' and so on. Then we have no less than *eighteen* rules to enable us to discover the form of the thief: if Mercury is in the sign of the Scorpion, he will be bald, while another planetary condition gives him height, and crisp yellow hair; some signs show him to be stout; others, a monster of a deformed body, others strong and patient, while Saturn or Mars, in certain positions, show that he is blood-thirsty and about to perish by a violent death, which at once relieves the astrologer from further anxiety, except as to his stolen goods. And this was dignified by the name of *Judicial Astrology*, and called an *Art*! Enough has been said, we think, to show how utterly trivial were many of the applications of this rankly superstitious practice; at the same time, it is impossible for us in the present day to fully realise the extent of the belief in the influence of supernatural causes in the time of Fludd. It was in every way a superstitious age;

let us remember that the belief in witches and demons, spells, conjurations, philtres, and raisings of the devil was as firm then amongst all classes of society, as it is now in many a lone hamlet in Cornwall, and many a green village of Galway, or of Wales. But is there not much superstition of one kind or other elsewhere? Ay, let us each think of our own pet superstitions, and of those of the age, before we cry shame on the astrology of Robert Fludd.

And now one word in conclusion as to the general character of the philosophy of Fludd. Eminently a syncretist, he endeavoured to unite the dominant tenets of many and diverse philosophies by means of a cement furnished by his own active and comprehensive intellect. I suppose that his philosophy is tinctured with somewhat of almost every system which had gone before. The base of his system is sunk deep in Eastern soil, the summit is obscured by mists of Middle Age origin. Chaldaic astrology and divination, Arabic geomancy and magic, the theurgy and theosophy of the Neo-Platonists, the aphorisms and tenets of the supposed Hermes Trismegistus with the paraphrases of Cornelius Agrippa, the traditions and the dreams of the Kabbalists and Talmudists, Alchemical and Paracelsian visions and dogmas, and a spice of the learning of the Ancient Greeks—let all these be united with much show of relevancy by an indubitably fertile and astute intellect, and let the whole be pervaded by a strong undercurrent of Christian tenets, and you have the philosophy of Robert Fludd. A philosophy, I need not say, utterly undefinable: a wondrous blending of the ancient thought of the Eastern world with the modern thought of the Western world; a union of Christian with barbaric lore, of the wisdom of the Ancients and the reveries of the East with the unfledged crudities of the Renaissance. A mixture of infinitely grand ideas with the wildest vagaries ever conceived by the mind of man; reverential here, almost blasphemous there; pantheistic and materialistic; sublime in one place, ridiculous in another. A philosophy in which wisdom and folly are seated at the same table, while Fludd acts as their host and endeavours to reconcile them: a philosophy based on supermundane influence; all symbolical, all theosophical, all occult; in which an assumed influence becomes the arbiter of destinies, and the philosopher himself a thaumaturgus.

The philosophy of Fludd could not exist in the face of the great intellectual movement which, in regard to all matters of philosophy and science, glorified the seventeenth century.

It could not endure side by side with the works of Bacon and Galileo, of Descartes, Pascal, Hobbes, Boyle, and of the many great thinkers which distinguished that epoch. With it perished a great mass of mystic lore. The philosophy of Robert Fludd was as a lurid flame upon an altar, hidden in the recesses of a darksome cave, the abode of demons and unearthly forms. The philosophy of his contemporary, Francis Bacon, was as a pure light set upon an eminence, which, like the diamond in the old story, diffused its luminous influence far and wide. It still diffuses it, for it is the '*lumen siccum ac purum notiorum verarum*,' while the altar has been overthrown, the cave is desolate, and the lurid flame has died out for ever.

The following Members were elected:—

Honorary.—Rev. B. Hartnell, M.A.
G. F. Rodwell, Esq., F.R.A.S., F.C.S.

Ordinary.—R. Bamford,
W. H. Thurtell,
A. Kent,
J. J. Hewson,
W. Woodhouse,
W. A. Smith,
J. P. Bush,
A. Haywood.
A. E. Batchelor,
W. M. Adey.

Present, 57 members and visitors.

MEETING, October 14, 1870.

The President in the Chair.

The minutes of the previous meeting having been read and approved, S. H. Leonard read the following Paper:—

ON THE 'HONEY BEE' (*APIS MELLIFICA*).

From times of the remotest antiquity, the bee has deservedly created more interest and attracted more attention,—certainly than any other *insect*,—and possibly more than any other member of the lower animal creation. It has at some time or another been the study of almost every naturalist; the geometrical regularity of its cells has excited the wonder and admiration of the mathematician; its remarkable instinct, its industry and perseverance, have been the theme of the moralist and inspired the muse of the poet, and its admirable constitution and polity have instructed the statesman and political economist. Its rich and beautiful productionshave

always been prized, not only on account of their own intrinsic value, but as indicating the vicinity of a fertile country, teeming with rich and luxuriant vegetation. To the agriculturist the bee is especially useful, both on account of the golden treasures of the hive, and because its presence is absolutely necessary for the fecundation of certain plants.

Amongst its historians in early ages may be mentioned especially Aristotle and Virgil, while among those who have done most in modern times to enlarge our knowledge of bee-management, Hüber, Swammerdam, Maraldi, Schirach, Reaumur, Bonnet, and Hunter stand pre-eminent. The genus 'Apis' includes over 250 species, but of these the best known and most studied is the 'Apis mellifica.' Our knowledge respecting bees has been of slow and gradual growth, and was exceedingly limited before the discovery of glass hives adapted for the observation of the internal management of the stock. The tribe 'Apes' belongs to the hymenopterous order of insects and to the section Aculeata.

The honey bee is rarely found in a wild state in this country, but instances do sometimes occur of swarms settling in hollow trees or old barns, and several swarms have been known to settle in a church tower. Every swarm consists of three descriptions of bees—the working bee, sometimes, but erroneously, called a neuter, the male or drone, and the female or queen bee.

The working bees constitute by far the largest number of the whole community; an ordinary stock consisting of 8,000 working bees, scarcely as many hundred drones, and seldom more than one queen. The working bees are distinguished by the smallness of their size, and their lengthened proboscis. Like the drones and queen, they have four wings and six legs, of which the two hindermost are the longest. On the outside of the middle joint of these there is a cavity, peculiar to the working bees, where they stow the materials they collect for making wax. Some authorities have stated that the working bees divide themselves into four companies, one of which collects honey and wax, another builds the combs, a third finishes them off, while the fourth provides food for the stock: it is further asserted that these four companies constantly relieve each other; but these statements are probably fanciful. It is certain, however, that separate detachments of bees have distinct duties assigned to them; for instance, a number of bees form a body of pioneers and watchmen. A few days before a queen leads off a swarm, some bees are sent out to select a suitable spot for the new

colony: these have often been observed, for several days previous to the migration of a swarm, hovering round a hollow tree and exploring every nook and corner. Other bees are employed in ventilating the hive, of which more anon; others are said to watch the signs of the weather and the state of the wind. A bee is seldom caught in a shower, however sudden; sometimes, when *we* perceive no change in the air whatever, the bees, though working with great assiduity, hurry within the hive; and the event proves their fears to have been well grounded. Gathering clouds produce this effect on them, and I have often been told that a swarm can be easily brought to the ground by scattering sand over them, which they mistake for rain. Bees possess a standing army ready to attack an invader and eject him from the hive; a detachment is frequently placed near the entrance to act as guards. All the work of the hive is done by the working bees; the drones collect no honey, and the queen bee leaves the hive once only, except when she leads off a swarm. About four or five days after the egg of the working bee has been deposited, the larva is hatched. The eggs are of an oval shape and of a bluish-white colour. The larva is like a small white worm coiled up at the bottom of the cell. Its food consists of pollen, mixed with honey and water. The larva is fed by nurse bees, and as it grows stronger, it changes its skin. On the fifth or sixth day it attains its full size, and the other bees close up its cell with a mixture of wax and propolis. It then ceases to eat, and employs the next thirty-six hours in spinning its cocoon. It remains in the chrysalis state for a week, and then emerges from its cocoon a perfect bee. Till within the last few years, the working bee has been considered to be of no sex, but it is now proved beyond a doubt that the queen bee and the worker are both developed from the same kind of larva. While the drones are destitute of a sting, the queen bee and the worker are both endowed with one, and all the organs of the latter are essentially the same as those of the queen bee, though some are more, some less, developed. For the discovery of the sex of the worker, we are indebted to Schirach, who, on first announcing his discovery, was met with incredulity and contempt. But the question has since been put beyond all dispute by the experiments and observations of later apiarians, and especially of Hüber. The drones, or males of the community, are distinguished by the absence of sting, and by the peculiar buzzing sound which they emit while flying. They are considerably larger than the worker, and even than the

queen, though not so long in the body as the latter. The proboscis of the drone is much shorter than that of the working bee, and therefore some have assumed that he cannot collect any honey even for himself. Others allege that he leaves the hive sometime after eleven o'clock, and that after lazily culling the sweets of the flowers all day long, he always returns before six in the evening. His body is thick, his head round, his eyes large, and his wings are rather longer than his body. The thorax is thickly covered with short brown hairs, and its shape is somewhat flattened. The number of drones in a hive varies from 800 to 2,000, and is not regulated by the size of the swarm. In three days after the egg has been deposited in the cell, the larva is hatched, and on the seventh day after, it spins its cocoon; having gone through the same metamorphoses as a working bee, it appears on the twenty-fourth day in its perfect form. The drones are bred later than the workers. Towards the end of July, when the drones have accomplished the object of their creation, they are killed and ejected from the hive, and never is a drone found in a hive later than September.

The queen bee is longer than either of the others, though her wings are shorter; she is provided with a sting and with two large ovaria, and is of a dark brown colour. The head is covered thickly with yellow hairs, and on the vertex are three small simple eyes, or stemmata. Her hinder part tapers more than that of the other bees, and is much longer. There is only one full-grown queen in a hive at one time, and she is treated with great care and attention by her subjects. If the queen dies, or is removed from a hive, the workers quickly perceive her absence and great commotion ensues; but within twenty-four hours this ceases, and order is restored, while the workers prepare to replace her loss. The larvæ of workers are selected for this purpose, and the adjoining cells are enlarged into oval cells forming the royal comb. A peculiar kind of food, which appears to be more stimulating than that given to worker bees, is administered to them. In a few days a tube is formed connecting the cell in which the larva is, with the oval cells already mentioned. Into this the larva makes its way; and having spun its cocoon, comes forth a perfect insect on the sixteenth day. The other bees undo the covering enclosing the queen, both to free her from the cell in which she has been hatched, and to get rid of the noxious effluvium. From the way in which bees replace the loss of their queen, as well as from many

experiments of Shirach's, it is clear that the grub of the worker is the same as that of the queen bee. As several queens are hatched at the same time, the strongest stings the others to death, and is left mistress of the hive. The object of the queen's creation is, that she may deposit her eggs in the cells formed by the workers. In the first eleven months of her existence, the eggs she lays are destined to become worker bees; after that, she lays the eggs from which drones are produced; and at this period the workers begin to build the royal comb, which is generally suspended from the sides or end of another comb. The royal cells vary in number from three to about twenty. When the larvæ in the royal cells are about to become pupæ, the old queen gets violently excited; she communicates her agitation to many of the workers; their rapid movements raise the temperature of the hive, and at last a large portion of the bees, headed by a queen, rush forth from the hive. Sometimes, however, instead of swarming, the old queen kills the royal nymphs, and the hive remains *in statu quo*. While the pupæ in the royal cells are being developed, the queen shows a strong inclination to destroy them; but, to prevent this, the workers drive her majesty back. She then emits a peculiar sound which has the effect of arresting the movements of the workers, but on again endeavouring to move, the sound ceases, and the charm is dissolved. If one queen be removed, and a fresh one introduced at once, she is kept prisoner till she starves; if, however, the old queen has been lost eighteen hours, the new one is treated with more consideration; if the old queen has been lost twenty-four hours, the strange one is acknowledged as queen of the hive. Some assert that it is always a young queen that leads off the swarm; others, that it is always an old one: the question is still *sub judice*. Perfect order is restored in a hive a few days after the departure of a swarm, and often the same stock swarms once, or even twice, during the same season. A swarm in the early part of May is prized much more than a later swarm, because it usually consists of many more bees, and the new colony gets a longer season to work in. Soon after a swarm leaves a hive, it generally settles upon a tree or bush, previous to winging its final flight—some say to rest the queen. It then rises perpendicularly, and darts off with great velocity to its final resting-place. I have been told by a bee-keeper that the best way to arrest their flight is, to squirt them with a syringe, thus causing them instantly to alight. Some authorities assert that bees have an acute sense of hearing, and

that the noise produced by pokers and tongs, drums and kettles, causes them to settle. Virgil makes mention of this in the lines—

> Tinnitusque cie, et Matris quate cymbala circum:
> Ipsæ consident medicatis sedibus, ipsæ
> Intima more suo sese in cunabula condent.—*Georg. IV.* 65.

It has been ascertained, however, that bees are insensible to such sounds as a clap of thunder or report of a gun. The structure of a bee includes many interesting parts. The trunk, or proboscis, which is formed by a prolongation of the lower lip, or labium, serves the purpose of a tongue, and is used for the absorption of liquids. It is protected by a double sheath and is solid throughout; though some apiarians maintain that it is tubular. The muscles are admirably adapted for the extraction of nectar from flowers. When the bee settles upon a flower, it thrusts its tongue among the petals and stamina, and after sweeping it about through every nook and corner, it withdraws it covered with the precious liquid, which it passes through the pharynx into the œsophagus. The bee is furnished with two stomachs, or rather with a honey bag and a stomach. The first is a long narrow membranous tube, into which the honey passes from the œsophagus. It is quite transparent, and when full of honey is almost the size of a small pea. From this, the bee regurgitates the honey to fill the combs, while the portion intended to serve as nourishment passes into the second or real stomach. The wings of the bee are admirably adapted for rapid movement through the air. To the edges of the under wings are attached about twenty hooks, which the bee, when flying, hitches on to the edges of the upper pair. The three pairs of legs, with which the bee is furnished, are composed of several joints, and on the lower part of the two under pairs are thick bristly hairs, with which it sweeps off the pollen from the flowers. By means of the combined action of its jaws and feet, it rolls up this pollen into little pellets, which it places in the two cavities with which the hindermost pair of legs is provided. Each foot ends in two hooks, by means of which the bees hang on to each other, or suspend themselves from the top of the hive or side of the comb. In the middle of the foot is the sucker, which enables bees, flies, and other insects of the same order, to walk on surfaces with their body downwards. The mandibles, or upper pair of jaws, are the tools of the bee, with which it divides solid substances, though they are but little employed in eating. The antennæ, we might, analogically, call the

hands of the bee: by means of these delicate organs the bees converse with one another, and if they be deprived of them, they seem to lose the wonderful instinct with which nature has endowed them. They are perpetually in motion, and have a wonderfully keen sense of all surrounding objects; they even convey to the bee a knowledge of the state of the atmosphere. It is by the aid of these organs that the bee is able to carry on its exact and regular work inside the hive, in total darkness, and through them it perceives the loss of the queen, and communicates its alarming discovery to the other bees. The abdomen of the queen and workers is furnished with a sting, consisting of two fine darts lying side by side, and enclosed in a sheath. These are pressed deeper and deeper into the flesh, and when the hooks have taken firm hold of it, the sheath follows, conducting the poison into the wound; this contrivance is often quoted as a combination of chemical action with mechanical apparatus.

I will now describe the history of a stock of bees, and will begin my description from the time when a new swarm settles in its new abode. It has already been mentioned that during the months of April and May, the queen lays a great many eggs, destined chiefly to become drones. This addition to the colony causes great inconvenience, owing to the increase of the temperature of the hive and the decrease of room. The old queen at this time deposits eggs in the royal combs, in order to provide a successor for herself, or a queen for the new colony. It is at this time that she is seized with the phrenzy to destroy the royal brood. Her excitement is communicated to the workers, and great confusion is produced in the hive. The rapid movements of the bees in this tumult cause the temperature to rise about 16°, that is, from 90° to about 108° Fahr. A large portion of the bees are now preparing themselves for their departure, by filling their crops with honey. A place for the new swarm has often been selected beforehand, in a hollow tree, or elsewhere, by the bees that acted as pioneers. But when a suitable place has not been found, or when the queen bee is too weak to accompany the swarm to the spot selected, they cluster round the branch of a tree or some other similar object. Not long ago a swarm settled in Temple Street, Bristol, and about the same time, another was seen winging its way across the College Close; and once a still more sociable swarm chose as its resting-place an old gentleman's head. When the swarm is settled in its new abode, the first thing to be done is, to construct some combs composed of workers'

cells. In these the queen immediately begins to deposit eggs, and on or about the twelfth day, the workers busy themselves in the construction of drone cells, and some time after this, they set about building the royal comb. To return to the parent hive: the eggs and the young brood fill up the places of the bees that have swarmed, and before long another swarm is given off. The number of succeeding swarms in a year is seldom more than two, but of course this depends on the quality of the pasture and condition of the hive. On the day fixed for the departure of the swarm, all the workers either remain inside the hive or hover round it. Near the middle of the day, often after a shower of rain, all the buzzing is hushed, and soon after, the swarm issues from the hive in a compact mass. Sometimes, however, a cloud or a shower obliges it to return to the hive. After the impregnation of the queen bee—generally in July or August—the whole drone portion of the community is indiscriminately exterminated. The workers hunt them down from all parts of the hive to the base, where they fall upon them, eject them from the hive, and sting them to death. They then destroy all the brood drones, and the drones belonging to other hives.

The autumn is spent by the bees in laying by food for the winter; at this time of the year their labours are less productive, except in the heath districts, since they have to collect their honey chiefly from leaves and fruit, instead of from the flowers of spring and summer. If their stock of honey fails, the pioneering force is despatched to reconnoitre the condition of the neighbouring colonies, and after the weakest hive has been selected, they sound their trumpets and march out in battle array, to invade the dominions of their neighbours. The aggressive army is met by the stock whose capital is besieged, and a fierce conflict ensues between the dense masses of each nation. Nor do the adjacent clans always preserve a strict neutrality; but actuated by an inordinate desire of plunder, instead of endeavouring to maintain the independence of a small but flourishing neighbour, generally connected with them by the closest ties of consanguinity, they join themselves to the host of the invader, completely sack the city, and appropriate the supplies accumulated by the industry, perseverance, and thrift of a nation reposing in peace.

Those who keep bees should feed them in autumn, so that they may not have to introduce the food in the cold months of winter. Various syrups are prepared for this purpose, or

treacle, sugar, or old pieces of honeycomb are introduced into the hive. The beginning of winter puts an end to the bees' yearly labours, and from this time till the beginning of spring they remain in a state of torpor. Sometimes, when the sun shines brightly on the snow, the bees are induced to leave the hive, but in such a case they seldom return, being frozen to death before long. The warm bright rays of early spring bring back the bees to the blossoming fields, and by the middle of May the colony is generally sufficiently flourishing to send off its first swarm. Immediately on taking possession of a hive, the bees coat it over with a substance called propolis. This is a resinous substance, of a peculiar, though not disagreeable, smell, which appears, from an experiment made by Hüber, to be principally derived from such trees as the wild poplar, though some have stated that it is the exudation of pine trees; others, that it is given off from certain vegetables. Be that as it may, the use to which the substance is applied is evident. The bees enter the hive with the propolis adhering to their legs, and are eased of their load by other bees, who remove it with their jaws. Every nook and corner is coated over with it, and likewise anything that is in the way—as, for instance, a snail. The next work that is commenced is the construction of comb for the reception of eggs. Wax is used for this purpose, which is produced by secretion. A number of bees fill their crops with honey, and hang themselves on to each other; the wax is presently given off from under the abdominal scales, and is removed through the assistance of other bees. Honeycomb consists of a number of hexagonal cells, opening on each side of the comb. For the benefit of mathematicians, I will quote a definition of a cell found in an Encyclopædia. 'The geometric form of each individual cell is a hexagonal prism, terminated by a trihedral pyramid, the three sides of which pyramid are rhombs, which meet at the apex of their obtuse angles, and forming oblique angles with the sides of the prism; truncate a portion of these, and convert them from rectangles, which they would be in a regular prism, into trapeziums.' I will now try to explain more simply the form of a honeycomb, and the geometrical regularity of its cells; but no description can be fully realised without the examination of the material itself. Each piece of comb is composed of two collections of cells, with their bases towards each other. Each of the interior cells is a hexagon, while the cells of the outside row are irregular pentagons. The base of each cell coincides with the centres of three

cells on the opposite side, and the arrangement is not base to base. The bees commence the building of their cells by making the bases in a plain sheet of wax; they then proceed to raise the sides. Wax when first formed is quite white; it gradually gets more and more yellow, and when very old it turns blackish. The cells are formed in such a way that the greatest possible space is enclosed by the least possible material. There are but three regular geometrical figures, which will severally form combinations without leaving interstices—the square, the equilateral triangle, and the hexagon. The body of the bee will not fit into the square without leaving the corners unemployed, much less so in the case of the equilateral triangle; but, owing to the size of the angle of the hexagon, very little space is left unoccupied in the cells of a honeycomb. The pyramidal base is also well adapted to the tapering form of a bee, and is prevented from slipping away by the three bases of the opposite cells enclosing it. Besides, if the bases were formed by a plain sheet of wax, the capacity of the cells would be much less. The economy of the bee is shown also in the construction of two sets of cells with their bases common to both. The combs are arranged parallel to each other, over the whole breadth of the hive, and generally reaching downwards to the bottom. A slight accident often alters the arrangement of the combs, and, as the space between each two is uniformly the same, an irregular formation in one comb often alters the whole. There are four different kinds of cells—the cells for the reception of honey, the drone cells, the royal cells, and the cells to contain the eggs which produce workers. The last named are by far the most numerous; the drone cells are rather longer than these, while the royal are nearly an inch long, and always vertically placed, and pear-shaped. Naturalists differ on the question as to whether honey undergoes any chemical change in the stomach of the bee, but in all probability it does not. Pollen is dust collected from the anthers of flowers, and mixed with honey and water, and it constitutes the food of the young bees; it is also eaten to a considerable extent by the other bees. It is by means of the pollen that female flowers are fecundated. Bees are extremely sensitive to the variations of temperature; the genial rays of the midday sun make them far more active in their movements, while the chilling cold of a winter's day quickly makes them insensible, and ultimately kills them. The temperature of a hive on a warm day is generally about 90° Fahr.; the brood cells are kept warmer than this by bees that

cluster round them for that purpose; the temperature of the hive, before swarming takes place, often rises about 14°. For the purpose of ventilating the hive, some of the bees fasten their feet to the base, near the entrance; they then violently vibrate their wings and thus produce a current of air. The presence of water near the hive is necessary for the prosperity of bees, and where there is none provided by nature, troughs should be placed containing it, at short distances from the hive. In one of the Science journals, there has been much discussion lately as to whether bees, during each excursion in search of pollen, confine themselves to one species of flower and those closely connected with it, or whether they roam at random from flower to flower. As a rule, it is probable, I think, that the bee derives its pollen from one species of flower only, but, under special circumstances, this general rule is superseded by the law of necessity. When gathered, the pollen is rolled up into little balls and put on the pair of baskets in the hinder legs. Among the plants and trees from which the bee derives its treasures, may be mentioned clover, honeysuckle, buckwheat, willow, poplar, sycamore, snowdrop, crocus, white alyssum, furze, heath, amaracus, thyme, mint, orange and lemon trees, and gooseberry, currant, and raspberry bushes. In all countries where bees are kept, both in ancient and modern times, it has been a custom to move bees about from one part of the country to another, in order that they may be employed in culling the sweets of the richest flowers, all the sunny months of the year. The Greeks moved their bees from Achaia to Attica; Pliny tells us the custom was prevalent among the Romans; the Sicilians moved their bees to Hybla, so that 'Hyblæa' has become a constant epithet of 'Apis.' In England, the inhabitants of the low lands remove their bees in the autumn months to the heath and furze of the hills. On the Rhine and Nile may be seen barges filled with bee-hives, drifting slowly along. There are many different kinds of bee-hives, constructed with great mechanical ingenuity; but perhaps the simplest way of managing one or two hives is, to put a bell glass over the top of a cottage hive. The practice of *destroying* bees is at once ruthless and wasteful, and it is impossible to realise the cruelty to the bees, without witnessing the destruction of a hive. Bees seldom die a natural death, as they are subject to the attacks of so many enemies. Among the most formidable, are bears, badgers, ant-eaters, swallows, bee-eaters, sparrows, toads, spiders, lizards, and poultry. Against these enemies barricades are often erected.

Among bee parasites may be mentioned the *Phora incrassata*, the bee-louse (*Braula cœca*), a kind of beetle called *Trichodes apiarius*, and *Meloe angusticollis*. Nothing is more interesting in the bee than the wonderful senses and instincts with which it is endowed. The vision of the bee is weak, but ample compensation is made by the antennæ. It is through the medium of the antennæ that the bee has its keen perception of temperature and the state of the atmosphere. The taste of bees is imperfect; but the sense of smell is exceedingly acute: many naturalists suppose that the bee is directed to the flowers by the smell of the honey. With regard to the instincts of bees, it is hard to judge accurately how far natural impulses, and how far knowledge acquired by experience, lead to the wonderful results we see. In no state, however well governed, is the division of labour observed with such unity, harmony, and success, as in a bee-hive.

W. Ffooks read a paper on 'Cetacea.' The President having invited the members to make any observations on the paper, E. O. Ashby, Esq., O.C., made some very amusing remarks, chiefly based upon his own experience and investigation.

Present, 82 members and visitors.

MEETING, Oct. 28, 1870.

The President in the Chair.

The minutes of the preceding meeting having been read, the Rev. J. Greene gave the first of a series of papers on 'Insect Life.' The paper was illustrated with a large number of Diagrams, drawn and coloured by Mr. Greene himself. The following is a short summary of the paper:—

Having explained the characteristics of a true insect, he briefly touched upon the six great orders into which they are generally divided, giving examples of the habits and transformations of some of the more noticeable species, as the Carpenter Bee, the common Gnat, &c. &c. Passing on to the order *Lepidoptera*, commonly known by the name of 'Butterflies and Moths,' he entered at great length into their 'life history,' from the egg to the imago. They were readily to be distinguished from all other insects by a vast number and

variety of 'scales,' or feathers. Examples of the different forms of these feathers were shown in one of the diagrams. They were arranged on the wings in great profusion, and generally in a double layer. Mr. Greene next drew attention to the prodigious number of eggs laid by some insects, and to the rapid increase in size of the larvæ, or caterpillars. In reference to these points the following extracts will be read with interest:—'A caterpillar which has been feeding not longer than a month or five weeks will be at least 4,000 times larger than when it first emerged from the egg. The caterpillar of the "Goat Moth," which feeds for three years, is 72,000 times heavier than when newly hatched, and the caterpillar of the "Silkworm Moth," which, when born, only weighs the 100th part of a grain, will, in thirty days, have consumed 60,000 times its original weight. . . . It will be obvious, from what has already been said of their eating powers, that caterpillars must be terribly destructive if their increase be in proportion to their voracity. That this may be so, and often is, will be seen from the following "statistics:"—The female wasp lays 30,000 eggs—the queen bee 50,000; a little insect observed by two eminent French naturalists produced at the fifth generation —which took place within three months of the first—five thousand nine hundred million individuals, or nearly six times the population of the globe. The female white ant lays her eggs at the rate of 60 per minute, or 3,600 per hour, so that in the short space of twenty-four hours she finds herself surrounded by a little family of nearly 90,000 individuals. How long she continues in this prolific mood I am unable to say. But it is among the Aphides that we find the most prodigious multiplication. Professor Owen, an indisputable authority, has proved that a particular species will, in twelve months, produce ten generations, each averaging 100 individuals, so that, in the short space of a year, a single parent may see herself the happy mother—if that be the correct term—of a progeny which requires the figure 1 and thirty ciphers to represent its numbers.'

A paper (the first of two upon the same subject) on 'Atmospheric Electricity' was read by W. J. P. Wood. The first principle laid down was, the attraction and repulsion of electricity to form itself, according as like or unlike kinds are presented to each other. This was illustrated by several experiments. Next, statical induction was treated of, the Leyden jar considered, and the principle applied to the thunder-cloud, the nature of the discharge being explained and experimentally illustrated by the perforation of card,

the inflammation of spirit, gas, &c. The most likely places in which to be struck were then mentioned, and, after a general treatment of the disruptive discharge in the air, the use of the lightning conductor was pointed out, further details being postponed until the next lecture.

The President communicated some extremely interesting observations which he had made on the development of a species of Vorticella.

Present, 98 members and visitors.

EXTRAORDINARY MEETING, Nov. 4, 1870.

The minutes having been read and approved, W. J. P. Wood read a paper on 'Atmospheric Electricity.' This paper, which was a continuation of the one read at the previous meeting, was illustrated with some beautiful and interesting experiments.

Visitors having withdrawn, the names of the following candidates for the title of 'corresponding members' were brought forward, viz.:—

A. Cruttwell, O.C., proposed by J. Stone, seconded by W. J. P. Wood.

E. O. Ashby, O.C., proposed by W. J. P. Wood, seconded by J. Stone.

A. W. Brodie, O.C., proposed by R. W. Wilson, seconded by P. R. Ogle.

T. W. Shaw, O.C., proposed by R. F. Brunskill, seconded by R. W. Wilson.

W. F. Howlett, O.C., proposed by P. R. Ogle, seconded by J. Allen.

All the candidates, having been balloted for, were declared duly elected, and the meeting then adjourned.

Present, 87 members and visitors.

MEETING, Nov. 11, 1870.

The President in the Chair.

This was the first of an experimental series of meetings to be held occasionally in 'Big School,' when, from the presumed interest of the papers to be read, or communications

to be made, a larger attendance of members and visitors than could be accommodated in the usual place of meeting might be anticipated. That, in the present instance, the Committee were fully justified in making this change may be gathered from the fact that no less than 176 members and visitors were present. Among them were a considerable number of ladies, the Rev. J. Percival (Head Master), the Rev. H. J. Wiseman, C. J. Peile, Esq., and others interested in the well-being and prosperity of the Society.

The minutes of the preceding meeting having been read and approved, the President called upon the Rev. J. Greene to read the second of his papers on 'Insect Life.'

Having briefly recapitulated from his first paper the facts which he had there brought forward to illustrate the prodigious fecundity of insects, and the voracity of their caterpillars, Mr. Greene mentioned some of the many causes which combined to arrest their undue increase, mentioning the facts—that many of the eggs never hatched; that, where they did, many of the larvæ produced from them died in the process of moulting their skins; that whole broods were frequently swept off by a peculiar disease, commonly called 'muscardine,' as in the case of the silkworm; that vast quantities were devoured by birds, especially in the breeding season; . . . 'but the most wonderful, and at the same time the most efficacious mode of repressing their undue increase (I speak now of Lepidopterous larvæ) is by means of what are called "Ichneumons,' nearly all of which belong to the orders Hymenoptera and Diptera. These insects pierce through the skin of the devoted caterpillar, and deposit within its body one or more eggs. The larvæ produced from these eggs feed upon the unfortunate caterpillar's interior. It sometimes dies almost immediately, but much more frequently goes on eating till quite full fed, when the skin bursts and liberates the ichneumon; or it (the ichneumon) turns into a chrysalis, sometimes inside, and, at others, outside the body of the caterpillar, which then shrivels up into a dry and shapeless skin. I have only once *seen* the operation. On one occasion, when examining a shrub for larvæ, a small caterpillar dropped from it, suspended by a thread. At the same instant a ferocious-looking ichneumon suddenly grasped the unfortunate little caterpillar, and, with almost lightning speed, transfixed it three or four times with its slender ovipositor, and then, having accomplished its evil work, departed. For a few moments the caterpillar seemed stunned,

but soon wriggled back, by means of its thread, to the shrub, and recommenced eating, apparently none the worse. But it was doomed! The number of larvæ destroyed by these ichneumons is enormous, and, speaking from my own experience, I have little doubt that, of every ten, half at least perish from their attacks. I may add that, in some cases, the ichneumon pierces even the egg itself. The *number* of eggs deposited in the body of a caterpillar varies from one to a hundred, or even more. I have myself seen no less than eighty little ichneumons issue from the body of a small larva belonging to the genus Eupithecia (Lep.).'

In illustration of the foregoing, Mr. Greene exhibited examples, viz., a dipterous ichneumon, which had emerged a few days before from a chrysalis—a larva similar to the one alluded to above (*Eupithecia albipunctata*), and at that moment crammed full of ichneumons; and, lastly, a cellular substance collected about a small twig, which had been produced by a number of ichneumons, which had emerged from the body of a caterpillar, observing that this was the most remarkable example he had ever met with.

He then, by means of coloured diagrams, explained how the caterpillars of butterflies pass from the larval to the pupal or chrysalis state, and entered into full details of the various kinds of cocoons, wood, moss, earth, silk, &c. in which the pupæ of moths shelter themselves during that period of their existence, and exhibited a box containing upwards of 200 chrysalises, cocoons, &c. The examination of these excited a good deal of interest and surprise. As a proof of the strong *gnawing* power possessed by some caterpillars, he gave the following little anecdote :—' I remember, when I first began to collect, finding a full-grown larva of the common "Puss Moth." Handling it with much tenderness, lest I should hurt it, or, to speak more correctly, lest it should hurt *me*—for, to own the truth, I was horribly afraid of it—I brought it home and placed it in a box with a gauze cover. It is hardly necessary to say that, when I examined the box next day, the Puss Moth was gone, and I distinctly remember shedding tears over the loss. Some months after, in removing the table-cover, I found it adhering to one of the legs, and there I found my missing caterpillar. Having escaped from the box, it had very sensibly walked down the leg, and finding it to be a suitable spot for its purpose, had scooped out the solid mahogany with its jaws, placed itself within, made a roof of the abraded particles, and finally attached to its cocoon the table-cover, in order to ensure warmth and comfort.'

Having made some further observations upon the methods employed by different insects in order to escape from the pupa, and thus enter upon the final, and, apparently, the happiest stage of their existence, Mr. Greene concluded his paper, and upon resuming his seat was much applauded.

P. R. Ogle read the following paper on

OZONE.

In 1785, Van Marum, at Haarlem, while making some experiments upon the newly-discovered element—oxygen, first noticed and called attention to the peculiar odour attending an electric discharge through this gas, and the action of oxygen possessing this odour upon mercury, namely, that of tarnishing it. Its nature he did not indicate, nor did he advance any theory respecting its formation, but contented himself with ascribing it to the natural odour of the 'electric matter.'

In 1840, M. Schönbein, of Basel, who was also the inventor of gun cotton, first commenced his series of researches which ultimately revealed to chemists the probable constitution of this principle, which is one of the most remarkable discoveries of late years, and has attracted much attention. At first he imagined it to be a simple electro-negative substance, analogous to, and in the same class as chlorine, bromine, and iodine, its analogy to chlorine being most striking: (i.) it is poisonous; (ii.) it bleaches; (iii.) it removes noxious miasma and sulphuretted hydrogen; (iv.) its odour is something alike when concentrated, and exercises an irritating action upon the respiratory organs. In his second paper on the subject, he threw out some hints that it might be a constituent of nitrogen; subsequently, he considered it to be a compound of oxygen and hydrogen, analogous to peroxide of hydrogen (H_2O_2), which is a syrupy, transparent, colourless fluid, resembling water. It is a powerful bleaching and oxidising agent, owing to the ease with which it parts with half of its oxygen, and may be prepared by acting upon baric dioxide (BaO_2) with hydrofluosilicic acid ($2HF.SiF_4$). Baumert, Williamson, and other chemists advanced the theory that the 'ozone' produced in electrolytic oxygen was teroxide of hydrogen (H_2O_3), while that produced by electric discharge consisted of peroxide of hydrogen (H_2O_2). These opinions were generally received in the chemical world, until MM. Marignac and de la Rive conceived the idea that ozone might in no respect differ from oxygen in composition. This suggestion was examined

experimentally, in 1852, by Messrs. Fremy and Becquerel, and fully verified. Schönbein, pursuing the same course of investigation, had arrived at the same conclusion, namely, that ozone was only electrified oxygen, or oxygen in a peculiar state of chemical affinity or allotropic modification. These results were arrived at by the consideration that they were able to procure ozone from pure oxygen, without any contact with hydrogen at all, by the passage of an electric discharge. In 1852, Becquerel and Frémy proved that the whole of any given volume of oxygen could be entirely converted into ozone, provided that the ozone, as formed, was absorbed by oil of turpentine, the absorptive power of which had only been recently made known by Soret. This clearly indicated its composition, and there is now every reason to believe that the much-discussed problem as to the constitution of ozone has at last been solved. Ozone—originally discovered by the odour of an electric discharge—is thus produced in Nature during thunderstorms, auroras, &c.; and it has been said that plants during the night emit this remarkable principle, and that part of the peculiar fresh smell which may be perceived in the early day is due to its presence, and hence the invigorating effect of the early morning air. It has also been said that ozone, in conjunction, of course, with the powerful bleaching properties of the chemical rays of the sun, plays an important part in the bleaching of linen spread out to whiten in many parts of the country. These facts appear to have been verified by Daubeny ('J. Chem. Soc.' 1867-69), who has demonstrated that plants, while growing in the sunshine, emit minute quantities of a body that liberates iodine from potassic iodide (KI), which is most probably ozone, since he at the same time proved the absence of chlorine and nitrous acid (N_2O_3), substances which act upon potassic iodide in a similar manner. There is a striking connection between the presence of ozone on the air and the existence of certain epidemic diseases, such as influenza, cholera, and the like. Ozone is generated in large quantities in the atmosphere during thunderstorms and other electric phenomena, as I have before mentioned; here, then, we have an explanation of the strong sulphurous smell which pervades the air where a shock has taken place, for this choking odour would naturally remind persons of the smell of burning matches (sulphurous acid); some observers have compared the odour with that of phosphorus. An unconscious testimony to the similarity of odour of a discharge of lightning is recorded by Professor Schönbein. A Swiss engineer named Buckwalder,

while upon the summit of the Senlis, near Appenzell, was suddenly involved in a thunderstorm. His servant was struck dead, and his tent was filled with the peculiar odour common to such occurrences. Chancing shortly afterwards to pay a visit to Schönbein at his laboratory, where he was engaged in the prosecution of some researches upon ozone, the smell of which pervaded the apartment, the engineer exclaimed with surprise that it wa the identical odour he had perceived upon the summit of the Senlis. This identity has been fully proved, as I shall further on have occasion to notice.

The connection between the presence of ozone and the existence of certain epidemics, has given rise to some curious speculations. 'Ozone,' says Mr. Hunt ('Athenæum') 'is constantly produced in the atmosphere under every circumstance which determines either electrical or chemical changes.' Both animals and vegetables are constantly throwing off minute particles of organic matter, whether in a state of health, disease, or death, and these particles are in that condition most fitted for recombination with the chemical elements of the air. These exhalations would speedily become far more injurious to all forms of animal life upon the globe than the carbonic acid to which they are reduced by oxidation, the work of the ozone, were it not for their removal. Ozone is thus, so to speak, the great natural scavenger employed to remove any noxious organic particles from the air, and convert them into innocuous forms of matter. Since the discovery of ozone and development of ozonometry, the year 1849 stands out conspicuous for the remarkable low electrical intensity of the atmosphere during the summer and autumn months, and since this is the only source of ozone in any practical consideration, it follows that this important chemical agent must also have been materially diminished in quantity.[1]

The following is a table of the mean electrical intensity of that year, accompanied by the mean of the five preceding years according to M. Quetelet:—

Month	Means of 1844–48	Means of 1849	Month	Means of 1844–48	Means of 1849
January . .	53°	39°	May . . .	21°	16°
February . .	47	36	June . . .	18	13
March . .	38	27	July . . .	19	14
April . . .	27	20	August . .	21	21

[1] 'Ozone varies in amount in an exact ratio with the electrical intensity.'—R. Hunt, *Athenæum.*

Mr. Glaisher and others have observed the same peculiarities.

Some curious observations have been made on the effect of the absence of electricity in the air. Magnetic intensity diminishes, and the electric telegraph has often refused to act. M. Andraud, referring to a powerful electric machine, capable at ordinary times of giving out sparks in profusion, in a letter to the President of the Academy of Sciences of France says, 'From the time the epidemic became general, I was no longer able on any single occasion to produce a corresponding effect. During the months of April and May sparks could only be procured after violent action. . . . . These fluctuations were then observed to coincide most exactly with the fluctuations of the cholera! Nevertheless, I was afraid lest the irregularities of the electric machine should have been occasioned by the hygrometric state of the atmosphere. I waited with impatience the arrival of fine weather, to enable me to continue my observations; but far from the previous indications of the machine showing any signs of diminution, they only became stronger; for although with the improved weather an augmentation of electricity might have been expected in a few days, the signs of its presence ceased altogether. On the 4th, 5th, and 6th of June it was only possible to obtain a slight crepitation, and on the 7th the machine became *dumb*. This singular decrease in the electric element fatally accorded with a consentaneous increase of the cholera. On the 8th feeble sparks reappeared and increased in number and intensity. In the course of the day a thunderstorm announced to plague-stricken Paris that electricity had once more entered in its dominion. On the 9th, at the slightest touch the machine gave forth sparks in abundance. Meantime the cholera was rapidly subsiding.'[1]

In 1865 an exceptional freedom from cholera, although ozone was absent, was observed at Lyons, Birmingham, Berlin, and other towns possessing metal manufactories.

Cholera is, generally, rapidly followed by influenza. Dr. Moffatt was the first to notice that 'the prevalence of influenza and the spread of catarrhal affections are invariably connected with an excess of ozone in the atmosphere.'

In the air of large towns and any enclosed spaces, where animals are contaminating the air with their breath, and the products of combustion from illumination, and other causes, set free into ill-ventilated apartments, ozone is entirely absent or deficient in quantity, and these are the places of

[1] Chemistry of Creation.

all others in which fevers and other contagious diseases effect such awful ravages.

In August 1855, tests for ozone were applied in each of the wards of the military hospital at Metz for twenty-four hours, and were for several consecutive days without affording the slightest trace; while, when suspended outside the windows, it was immediately detected. Similar results have been obtained under like circumstances. Dr. Berigny in the Versailles hospitals found that test papers which, for fifteen days inside the wards would give no trace, exposed outside, and even in an empty ward, gave instantaneous indications. At the same time ozone was remarkably deficient in Paris—the tests exposed at the Conservatoire des Arts et Métiers giving no trace. Thus it appears that the vitiated state of the atmosphere is sufficient to account for the lack of ozone. The amount of animal matter in air is tested by the exposure of a solution of permanganate of soda, which is decolourized and decomposed by organic matter (the permanganate being reduced first to manganic acid, and subsequently to the dioxide by the oxidation of the animal matter). May we not from this infer that the health-giving influences of a country walk are due to the presence of ozone, since ozone exists wherever there is active vegetation? From these considerations it has been concluded, that the presence of cholera and other diseases of a sporadic nature, is due to the absence or deficiency of ozone, while the presence of influenza and other epidemic catarrhs is due to an excess of ozone. Such a conclusion is somewhat hasty, and has lately met with some severe criticism. 'Are these epidemics,' says M. Naquet, 'owing to the disappearance of ozone, which being no longer in sufficient quantity to destroy the miasmata, enable these to accumulate, or are they not owing to the production of such a quantity of miasmata that the ozone is not sufficient to destroy them?' In short, 'Are epidemics,' says he, 'the cause or result of the disappearance of ozone?' This is at present undetermined; opinion inclines towards the supposition that these epidemics are the cause and not the result of the disappearance of ozone. Dr. Moffatt has made some researches at great length upon the medico-meteorological effects of ozone, and has demonstrated that the quantity of ozone present in the atmosphere is greater when the barometrical pressure is below the mean than when above; that it is more abundant on the sea coast than inland, on the west than east of Great Britain, on elevated than on low situations, in south-west than north-east winds, on the wind-

ward than leeward side of the land, and between February than June than between July and January. (August 29 and September 2, 1859, especially remarkable for large quantity of ozone present.) Schönbein supposes that ozone plays an important part in the chemistry of respiration and combustion; the latter can be shown by blowing with a pair of bellows against a Bunsen's gas burner, when the peculiar odour of ozone will be perceived.

An important function of ozone in nature is the destruction of all noxious organic particles in the air, such as are evolved from fevers and other infectious diseases, and from decomposing vegetable and animal matter. These foreign ingredients are reduced by oxidation, by the oxygen, and ozone of the air, successively, to simpler and simpler forms, till converted either into beneficial constituents or innocuous forms of matter. The hydrogen and carbon are respectively reduced to water and carbonic acid (CO_2), and the nitrogen set free. The carbonic acid is again decomposed by the action of sunlight and vegetable life, the carbon being received into the tissues of the plant while the oxygen is set free. There is reason to suppose that organic matter in process of decay has the power of developing ozone, which then reacts upon it. Thus is the atmosphere maintained in purity and constant composition. The air in its normal condition is said to contain about one ten-thousandth part of ozone. Small as this amount is there is every reason to believe that its functions are of the greatest importance. Ozone may be prepared by many processes; the following are the most worthy of note:—

(1) By passing a series of electric sparks from a frictional machine through dry air or oxygen, in the latter case the gas is diminished in volume by about $\frac{1}{15}$th.

(2) By passing the electric brush or disruptive discharge into air or oxygen from a moistened wooden point.

(3) By the passage of galvanic electricity, Andrews and Tait have ('Phil. Trans.' 1860, p. 117 et seq.) shown that the maximum amount is produced by passing the electricity silently; by operating upon sealed tubes of pure and dry oxygen they effected a contraction of $\frac{1}{12}$th, which they found in every case to be the limit, and the passage of the electric sparks caused the gas to expand till it recovered $\frac{1}{4}$ of the contraction, and had reached the point of contraction effected under any circumstances by the passage of sparks. This is caused by the heat of the sparks decomposing the greater part of the ozone produced.

(4) Siemens has devised an ingenious apparatus for the production of ozone by induction. His apparatus consists 'of a glass tube, about the size of an ordinary test tube coated with tin foil, or still better, silvered and enclosed in an outer tube lined outside with tin foil. The two tubes are sealed together at the neck of the outer one, and so adjusted that the space between them shall be as narrow as possible. At the projecting end of the inner tube is a brass button, which is connected by a spring with one of the binding screws on the frame of the apparatus, which screw is to be connected with one of the terminals of the secondary coil of an inductorium, and the other, with another binding screw in metallic communication with the coating of the exterior tube. The apparatus is, in fact, a sort of slit Leyden jar; and air or oxygen admitted through the lateral tube becomes, during its passage through the apparatus, powerfully ozonised.'

(5) By the electrical decomposition of water, acidulated slightly by means of an acid, as sulphuric (H_2SO_4), by means of the galvanic battery; by this process at the negative pole oxygen and ozone are developed in a mechanical mixture from which they cannot be separated by any means at present known. Hydric dioxide (H_2O_2) is also formed in minute quantities.

(6) By plunging a hot glass or iron rod into a bottle containing air or oxygen mixed with the vapour of ether ($C_4H_{10}O$), alcohol (C_2H_6O), oil of turpentine ($C_{10}H_{16}$), sulphuric-dioxide (SO_2), and some other ethereal oils and hydro-carbons. The residual contains peroxide of hydrogen (H_2O_2), and if agitated with a few drops of a solution of potassic chromate (K_2CrO_4) slightly acidulated with sulphuric acid (H_2SO_4), a blue solution of perchromic acid ($HCrO_4$) is formed. If this experiment (when performed with ether) is varied by the substitution of oxygen for air and a heated glass tube for the rod, an explosion takes place. This is explained by the supposition that ozone is liberated in such large quantities that the ether is oxidised with so much violence as to cause an explosion.

(7) By heating together three parts of sulphuric acid (H_2SO_4) and two parts of permanganate of potassium ($KMnO_4$); this Boettger states will continue to give off ozone for months.

(8) Houzeau states that the oxygen evolved from baric-dioxide (BaO_2) on the addition of sulphuric acid (H_2SO_4), contains ozone, and that the gas so prepared possesses its

peculiar odour, oxidizes ammonia (NH_3), and causes the less inflammable varieties of phosphuretted hydrogen (PH_3 containing minute quantities of P_3H_{10} (PH_2) and P_2H in suspension). 'Later researches have, however,' says the late Prof. Miller, 'rendered it probable that these properties are due to the formation of peroxide of hydrogen in small quantity, and to its suspension in the oxygen as it escapes.' (*Elem. Chem.* ii. 338.)

(9) By the galvanic decomposition of dilute sulphuric acid ($H_2SO_4 * H_2O$) or a solution of the sulphates (M'_2SO_4), chromates (M'_2CrO_4), phosphates (M'_3PO_4, M'_2HPO_4 or $M'H_2PO_4$), and other salts of the alkalis between poles of gold and platinum.

(10) By rubbing with a pestle in a mortar, or in water, or with carbonate of potassium (K_2CO_3), a blackish violet-coloured fluor spar (CaF_2) called Chlorophane. When a strong odour of hypochlorous acid (HClO) or ozone is evolved, hypochlorous acid and any other possible substances of the like character have been proved by Schrötter to be absent and ozone only present.

(11) When finely divided platinum and certain other metals are slowly oxidizing ozone and peroxide of hydrogen (H_2O_2) are evolved.

(12) Several hydrocarbons ozonize air when exposed to sunlight.

(13) The oxidation of several substances in moist air—such as oil of bitter almonds (C_7H_6O), sulphurous acid (SO_2), phosphorous acid (P_2O_3), oil of turpentine ($C_{10}H_{16}$), stibethyl SbC_6H_{15}), phosphorus, &c. The latter substance is the most convenient for manipulation. The operation may be conducted as follows:—Take a piece of clean scraped phosphorus (an exceedingly convenient method of cleaning the outside of the phosphorus is to melt it in a test tube under water, allow it to cool, and remove by breaking away the test-tube); place the stick of phosphorus at the bottom of a wide-mouthed jar, pour in water in sufficient quantity to cover half the phosphorus, cover the mouth of the jar with a glass plate, and allow it to stand in a temperature of from 60° to 70° F. (15° to 21° C) for about two hours, by which time the oxidation of the phosphorus will have been attended with the production of ozone. If the phosphorus is not now removed, it will recombine with the newly formed ozone, and thus destroy it. The formation of ozone will be rendered evident by the light luminous column of smoke which rises from the phosphorus, and is due to the formation of ammo-

nic nitrite (NH_4NO_2), the product of oxidation by ozone. Still keeping the glass plate in its place, the jar should be inverted over a pneumatic trough to remove the phosphorus. The gas should now be washed free from any vapour of phosphorus or phosphorous acid, when the contents are ready for experiment. By none of the foregoing, nor by any other process at present known, can ozone be procured free from admixture with other gases, but always in a state of mechanical mixture with from 50 to 200 times its volume of oxygen. It seems possible that the production of ozone by the oxidation of phosphorus in moist air may be thus explained. The phosphorus, while uniting with one portion of oxygen to form phosphorous acid, frees a corresponding portion as an allotropic modification known to us as ozone. A similar theory will account for the bleaching properties of sulphurous anhydide (SO_2) in presence of oxygen, one portion of oxygen going to the oxidation of the sulphurous acid, while another, as ozone, oxidizes the other body present. This theory is founded on Schönbein's hypothesis as to the constitution of ordinary oxygen. However ozone is prepared its properties are always identical. This identity has been proved (*Phil. Trans.* 1855 and 1860), by Dr. Thomas Andrews with regard to the ozone produced by statical and dynamical electricity and the oxidation of phosphorus in moist air. He bases his conclusions upon the following properties, which in all cases of ozone are identical, and are not common to nitrous acid (N_2O_3), chlorine, or any other compound which might be mistaken for ozone:—(1) The oxidation of mercury, silver, or other metals. (2) The ozonized air is destroyed by being passed over peroxide of manganese (MnO_2). (3) The action of heat destroys it, which certainly would not be the case with nitrous acid or chlorine, which he verified by experiment. These results were also confirmed by MM. Soret, Claus, and Von Babo in such a way as to utterly demolish the theory of Williamson and Baumert that ozone is a peculiar trioxide of hydrogen (H_2O_3). Ozone will be found to differ considerably from oxygen in having a singular metallic smell, somewhat resembling hypochlorous acid (HClO). It is poisonous—mice and other small animals will expire in an atmosphere containing even such a small proportion as $\frac{1}{6000}$ of ozone. Two millegrammes or $\frac{1}{33}$ of a grain is sufficient to kill a rabbit. It has been asserted that the cause of death by a stroke of lightning is due to suffocation by a large amount of ozone generated around the person struck. Even when largely diffused in the air it causes an unpleasant sen-

sation, making respiration difficult by acting powerfully upon the mucous membrane, and producing catarrhal effects.

It bleaches powerfully by oxidizing the colouring matter submitted to its action. This property can easily be shown experimentally by suspending in a jar of ozone some litmus, turmeric, indigo, or any vegetable colour, when it will be destroyed. Indigo (C_8H_5NO) is converted into isatine ($C_8H_5NO_2$); in the same way a rose or other flower is rendered colourless when brought under its influence. Mr. Edward Beanes has patented the application of ozone in the bleaching of syrup for the manufacture of sugar.

Combustion would doubtless take place in ozone, with great brilliancy could we obtain it pure from admixture with foreign gases, judging from the extraordinary oxidizing property it possesses. Gold, silver, iron, copper, zinc, cadmium, tin, lead, bismuth, &c., are, when moistened, carried to the state of peroxide or highest state of oxidation, by the action of ozone: according to Schönbein, this is accompanied by the disengagement of minute quantities of peroxide of hydrogen (H_2O_2). If the metals are dry, little or no effect is produced with the exception of mercury. Dry iodine also is oxidized by ozone. Ozone is quite insoluble in water, acids, or alkalies; but it is readily absorbed by a solution of potassic iodide (KI). Thus, if a tube of pure oxygen is inverted over a solution of potassic iodide (KI), and the gas subjected to a continual discharge of electricity, it will be entirely absorbed, potassic hydrate and iodine being formed:

$$4\,KI + O_2 + 2H_2O = 4\,KHO + 2I_2$$

This again reacts upon the water when potassic iodate (KIO_3), peroxide of hydrogen (H_2O_2), and peroxide of potassium (K_2O_4) are formed.

Ozone oxidizes ammonia, with the formation of ammonic nitrate. Thus—

$$2NH_3 + O_3 = NH_4NO_2 + H_2O.$$

Ozonized air oxidizes lime water (CaH_2O_2) to the nitrate ($Ca2NO_3$). It is powerfully electromotive, and is adiathermic, although oxygen is diathermic.

Dr. Emerson Reynolds has lately discovered that ozone entirely obliterates the latent image in photography, so much so that another image can be developed on the same plate without any change being necessary. He also thinks that this is the primary cause of the length of time necessary on some days for the production of a successful photograph. It is an interesting fact, since it proves that the production

of a photographic image is the result of a chemical change, and not founded on any mechanical theory.

The diffusive power of ozone is about that of carbonic acid. Its computed density is 1·658.

Ozone, even when extremely diluted, has the power of liberating iodine from iodide of potassium (KI), and on this property, in conjunction with that of free iodine, to form with starch ($C_6H_{10}O_5$), a blue compound is founded, one of the most delicate, although not characteristic, tests for its presence.

In March last year, M. Fontaine was making some experiments in his laboratory, near Paris, with potassic picrate ($KC_6H_2N_3O_7$), when it exploded with frightful violence without any apparent cause, blowing several persons to atoms, and among them M. Fontaine's eldest son. The state of the atmosphere was the only cause that could be assigned for the accident, and M. Houzeau, having observed that the quantity of ozone in the air at Paris on that particular day was higher than it had ever been recorded before, tried the experiment of introducing a small piece of picrate of potassium into a phial of ozone, when a frightful detonation took place and the phial was smashed to atoms. Nitro-glycerine ($C_{11}H_{67}N_{13}O_{16}$), dynamite, chloride and iodide of nitrogen ($HCl_2N.Cl_3N$ and HNI_2NI_3), and several other substances, whose constituent atoms are loosely held together, instantly explode on being introduced into an atmosphere of ozone. Ozone, when heated to 550° F (288° C) is reconverted into ordinary oxygen. Ozone is destroyed by contact with india-rubber, cork, and nearly all vegetable or animal substances; the hydrogen and carbon contained in the organic matter being oxidized to water (H_2O) and carbonic acid (CO_2). Ozone has no action upon the following substances:—

Urea (CH_4N_2O),	Hippuric acid ($C_9H_9NO_3$),
Allantoin ($C_4H_6N_4O_3$),	Alloxan ($C_4H_2N_2O_4$),
Creatine ($C_4H_9N_3O_2.H_2O$),	Cencine.
Fibrine ($C_{20}H_{31}N_5O_6$)	Gelatine ($C_{41}H_{67}N_{13}O_{16}$)
Starch ($C_6H_{10}O_5$),	Sugar ($C_{12}H_{22}O_{11}$),
Inosite ($C_6H_{12}O_6 2H_2O$)	Amygdaline ($C_{20}H_{27}NO_{11}3H_2O$),
Salicine ($C_{13}H_{18}O_7$),	Albumen (fresh) ($C_{72}H_{112}N_{18}SO_{22}$),

and some others.

In contact with ozone, albumen ($C_{72}H_{112}N_{18}SO_{22}$) becomes slightly coloured, and then forms a coagulum analogous to fibrine ($C_{20}H_{31}N_5O_6$), but insoluble in nitric acid (HNO_3); when it has absorbed the maximum possible it cannot be coagulated by heat, nor is it precipitated by mineral salts with the

exception of triplumbic dioxyacetate ($Pb_3O_2(C_2H_3O_2)_2$). The product of the oxidation of oil of turpentine ($C_{12}H_{16}$) is a resinous substance; of oil of bitter almonds (C_7H_6O) benzoic acid ($C_7H_6O_2$); of alcohol (C_2H_6O) formic acid (CH_2O_2); of tannic acid ($C_{27}H_{22}O_{17}$) oxalic acid ($H_2C_2O_4$), &c.; blood is so acted upon as to leave scarcely anything but a mineral residue. The presence of an alkali in all cases accelerates the oxidation of an organic substance by ozone.

The oxidizing properties of ozone are in almost all cases the basis upon which the tests for identification are founded.

(1) The iodine starch test paper is prepared as follows:— Slips of bibulous paper are smeared with the following composition; 1 drachm of white starch ($C_6H_{10}O_5$) mixed with 1 oz. of boiling water and the solution boiled, then 12 grains of potassic iodide (KI) are to be added, and the whole well mixed together. Schönbein recommends the proportions of 1 part of potassic iodide, 10 of starch, and 200 of water.

The prepared paper should be kept in a stoppered bottle covered with tinfoil to exclude hydric sulphide (H_2S), ammonia (NH_3), nitrous and nitric acid (HNO_2 and HNO_3), and light, otherwise a loss of colour will be the consequence.

The presence of potassic iodate in the iodide must be avoided, or conflicting results will be recorded in the presence of sulphurous acid (SO_2) and sulphuretted hydrogen (H_2S), gases of frequent occurrence in the air.

Ozone is indicated by the decomposition of the potassium salt, iodine being liberated, which combines with starch to form the blue iodide of starch. But since the same result follows from the presence of many other substances, the test, although extremely sensitive, is by no means characteristic. M. Houzeau has proposed a modification of this test, namely, red litmus paper dipped in a solution of potassic iodide; when decomposed the potash (KHO) will change the red litmus paper to blue; a piece of red litmus (without potassic iodide) must be suspended near, in order to see if any ammonia is present which would produce the same result.

M. Frémy has devised a test, consisting of blotting paper dipped in an alcoholic solution of guiacum ($C_5H_5N_5O + CH_5N_3$, &c.) dried in the dark.

Paper soaked in manganous sulphate ($MnSO_4$) indicates the presence of ozone by becoming brown; this is due to the absorption of oxygen, by which means the salt is converted into the hydrated peroxide (MnH_2O_3) and free sulphuric acid (H_2SO_4).

Paper stained with plumbic sulphide (PbS) is whitened by the formation of the sulphate ($PbSO_4$).

Silver leaf has lately been proposed as a test paper, but it is not likely to lead to any reliable results.

The best test is probably that devised by Dr. Van Huizuiga, namely, paper soaked with protoxide of thallium (Tl_2O); the action of ozone changes it brown, owing to the formation of the sesquioxide (Tl_2O_3). It is prepared by washing paper with a solution obtained by precipitating thallous sulphate (Tl_2SO_4) by baric hydrate (BaH_2O_2). It is calculated that on every square centimètre there is one millegramme of thallous oxide.

Ozonometry is at present very deficient, little being known of the actual amount present in the atmosphere. Most of the early observations on ozone in the atmosphere are vitiated by the knowledge that due precautions were not taken to ensure absence of mistake from the presence of other substances of like character. For the purposes of ozonoscopy, at present an arbitrary scale is used from 1° to 10°, determined by variation of colour on the iodine starch paper prepared by standard proportions.

Ozone differs from oxygen in the following important particulars:—(1) It has a strong odour. (2) It is poisonous. (3) It bleaches vegetable colours. (4) It liberates iodine from potassic iodide. (5) It destroys by oxidation deleterious miasmata. (6) Attacks silver, gold, and many difficultly oxidizable metals and decomposes almost all organic compounds.

Its resemblance to chlorine I have already traced. There is also a striking analogy between it and sulphuric dioxide, substances of the same molecular constitution; that is to say, the molecule of each consists of three atoms of diatomic elements similarly condensed. They both possess a peculiar and characteristic odour—are colourless and dense; both deodorize, disinfect, tarnish, and corrode moist metals, whiten paper stained with plumbic sulphide, are absorbed by a solution of potassic iodide, rendering the liquid yellow from the presence of free iodine, and also by oil of turpentine. Another modification of ozone, antozone, combines with water

$$O_3 + 3H_2O = 3H_2O_2$$

to form (peroxide of hydrogen) a liquid partaking of the properties of ozone, while sulphuric dioxide, when combined with water, also produces a liquid (sulphurous acid (H_2SO_3) possessing the properties of the gas; ozone reduces silver from

the ammonio-nitrate ($AgNO_3 2.H_3N$); sulphuric dioxide behaves in the same way with the nitrate ($AgNO_3$); the addition of manganese dioxide (MnO_2) destroys them both.

The analogy of ozone with hydroxyl (H_2O_2) is also most striking, both these bodies being also similarly constituted. In 1852 it had been satisfactorily proved that ozone consisted entirely of oxygen; the constitution of its particles had as yet evoked no enquiry. Schönbein, in a letter addressed to Professor Faraday, dated June 25, 1858, first propounded his elaborate and ingenious theory. It was followed in 1860 by an important paper by Andrews and Tait on the volumetric relation of ozone, in which they took the view of the case proposed by Dr. Odling—that ozone should be considered as a binoxide of oxygen (OO_2), while the molecule of ordinary oxygen as oxide of oxygen (OO).

They found that on agitating mercury with ozonized air no contraction followed, although the ozone entered into combination with the mercury. Two theories are here admissible; (1) that the ozone was in such a state of condensation that, in comparison with a great bulk of oxygen, no appreciable disappearance could be discerned; or (2) that a molecule of ordinary oxygen $\left.\begin{matrix}O\\O\end{matrix}\right\}$ was united with an atom of allotropic oxygen Θ, with condensation of one-third. Ozone will accordingly be thus represented—$\left.\begin{matrix}O\\O\end{matrix}\right\}\Theta$, and will contain a volume of ordinary oxygen equal to its own. On the oxidation of any substance the atom of allotropic oxygen is fixed, while the ordinary oxygen is liberated, and thus indicates no contraction. Soret finds that ozone is absorbed entirely by oil of turpentine ($C_{10}H_{16}$), and the decrease in volume is double that of the increase formed by the decomposition of ozone by heat, which is confirmatory of the second theory.

Schönbein found that when ozone is shaken up with hydroxyl (H_2O_2), oxygen and water only are formed, as represented in the following hypothetical equation:—

$$\Theta\,\Theta\,\Theta + H_2O\,\Theta\,\Theta = 2{\cdot}O\,\Theta + H_2O$$

in which Θ represents the allotropic modification of oxygen contained in ozone, and Θ the active principle of another opposite corresponding form, called by him antozone, these two modifications being in an opposite polar condition. The product of their union is ordinary oxygen, by means of the reciprocal neutralization of their electric conditions. Thus:—

$$\Theta\,O\,\Theta + O\,\Theta\,O = 3{\cdot}O\,O$$

Similarly, potassic permanganate ($KMnO_4$) and peroxide of hydrogen (H_2O_2) evolve oxygen, and hydrated peroxide of manganese (MnH_2O_3) is precipitated; also chromic acid (H_2CrO_4), sulphuric acid (H_2SO_5), and peroxide of hydrogen (H_2O_2) give off ordinary oxygen with the production of chromic sulphate ($Cr_2 3SO_4$); and again argentic oxide (Ag_2O) is reduced to the metallic state by peroxide of hydrogen. Thus :—

$$Ag_2\Theta + H_2\Theta\ \Theta = Ag_2 + \Theta\ \Theta + H_2\Theta$$

Such peculiar reactions are not characteristic of hydroxyl (H_2O_2) only; many other peroxides exhibit the same properties, viz., those of the alkalis, alkaline earths, &c. It is assumed that these reactions are due to the tendency to union between the two different modifications of oxygen contained in the substances brought into contact, it being supposed that the principle of ozone (Θ) is present in permanganic and chronic acids, and in barium dioxide, while that of antozone (Θ) is in the peroxides of hydrogen, manganese, &c. The following reactions Schönbein thought confirmatory of his theory :—

Baric dioxide (BaO_2), when acted on by hydrochloric acid (HCl), forms baric chloride ($BaCl_2$) and peroxide of hydrogen (H_2O_2), but when hydrochloric acid acts upon manganese dioxide (MnO_2), the hydrochloric acid is decomposed, and chlorine evolved. Thus :—

$$(1)\ BaO_2 + 2HCl = H_2O_2 + BaCl_2$$
$$(2)\ MnO_2 + 4HCl = Cl_2 + MnCl_2 + 2H_2O$$

And again, when sulphovinic acid ($C_2H_6SO_4$) is heated in the presence of baric dioxide (BaO_2), ether ($C_4H_{10}O$), bicarburet of hydrogen (C_4H_2), and sulphuric dioxide (SO_2) are the produce, but the substitution of manganic dioxide (MnO_2) for baric dioxide results in the production of aldehyde (C_2H_4O).

Nevertheless, hydroxyl can be prepared from both manganese and baric dioxides, but each hydric dioxide so produced is decomposed by the peroxide employed to form the other, and they will also decompose each other.

Von Babo's experiments appear to indicate that Schönbein's antozone is peroxide of hydrogen.

Sir B. C. Brodie has objected to this complicated theory of the existence of two opposite corresponding modifications of oxygen—ozone and antozone, but explains these decompositions by reference to the general laws of chemical change. He says (*Phil. Trans.* 1862, p. 852), 'No such fundamental

distinction exists between the properties of the different peroxides as that which it is proposed to characterize.' We are told that—

(1) An acid solution of peroxide of hydrogen (H_2O_2) causes the conversion of a solution of ferrocyanide of potassium ($K_4Fe_2Cy_6$) to that of ferrocyanide ($K_3Fe_2Cy_6$).

(2) An alkaline solution of peroxide of potassium (K_2O_4), added to a protosalt of manganese, forms hydrated peroxide of manganese (MnH_2O_3).

(3) An alkaline solution of peroxide of sodium (Na_2O_4) oxidizes an alkaline solution of sesquioxide of chromium, forming chromate of potassium (K_2CrO_4).

He also contradicts the statement of Schönbein that baric dioxide (BaO_2) and hydrochloric acid (HCl) will not evolve chlorine, stating that they will do so when *strong* acid is used.

On these and other experiments he bases an hypothesis, since generally adopted, that particles of the same element may under certain conditions possess a chemical attraction for each other, this being due to a different polar condition in the active particles, called by him the 'chemical difference,' and that no bodies can combine unless they possess this chemical polarity.

'Of the precise mode,' says Brodie, 'in which the chemical properties of its constituents exist, we are doubtless unable to give an account. We take the oxygen from the peroxide of sodium and transfer it to manganese protoxide; in the new combination it will no longer produce the effect of reduction. Again, we transfer the oxygen of the peroxide of barium to anhydrous acetic acid, and we form one of the most powerful oxidizing compounds with which the chemist is acquainted, while we can transfer this oxygen to baryta and restore it to its original properties. It is not the oxygen that is different, but the elements differ with which the oxygen is associated.' (*Phil. Trans.* 1862, p. 853.)

Whichever of these theories we admit, we have still every reason to consider the free molecule of ozone to be represented by O_3, while that of oxygen is O_2.

At earlier stages of the enquiry into the nature of ozone, Andrews conceived the idea that the density of ozone was fifty or sixty times that of oxygen. A little later he thought it to be eight times as dense. These opinions were, however, soon abandoned. The more recent research into its constitution would seem to indicate its density to be 1·6584. Ossan has made some experiments with regard to the atomic

weight of ozone; his results were not, however, satisfactory. It is generally considered to be 24.

The President complimented Ogle on the ability shown by him in the preparation of the foregoing Paper. G. F. Rodwell, Esq., F.R.A.S., F.C.S., having also spoken in laudatory terms of Ogle's Paper, made some interesting remarks upon 'Acoustics,' of which the following is an abstract:—'A mass of matter in a condition of stable equilibrium, when disturbed by the action of an external force, tends to return to its original condition. Example of the pendulum, alternating motion across a position of rest, vibrations, oscillations, waves, undulations, &c.

'Vibrations in solids, liquids, gases.—General character of each. Modes of producing vibrations. Parts of a wave, how distinguished—length, depth, height, breadth, depression, elevation. Nature of sound. Interference of sound, cause and effect. Organ pipes, tuning forks, &c.

'*Tartini's Beats.*—It has been shown by Weber, that if we rotate a tuning fork, there are four positions in which the sound disappears. If we look down upon the prongs of a tuning fork, we may draw lines indicating where the waves generated by the tuning fork interfere; and these lines are hyperbolic curves. Let us take a tuning fork furnished with a resonance box, and cause it to vibrate; it will emit a clear, even note. Now let us place the fork with its box on a whirling table, and cause it to rotate rapidly; immediately beats are perceived, which of course vary in frequency of recurrence with the rapidity of revolution. In addition to the cause pointed out by Weber, may it be possible that interference results from a second cause? For let a prong A produce a series of waves in a line *a b*, and let the fork be rotated with such a velocity that when A returns to its original position at one end of the line *a b*, the waves, which it now produces meet the waves which it before produced in such a manner that a depression of the former coincides with an elevation of the latter (or *vice versâ*) and hence interference. It may be worth the attention of the Society to enquire whether such a condition be or be not possible, and whether it may partly account for the effects observed.'

EXTRA MEETING, Nov. 18, 1870.

Rev. J. Greene in the Chair.

The Minutes of the preceding Meeting having been read, a Paper on the 'Microscope' was read by F. L. Penney, from which the following extracts have been made:—

'Since the introduction of the Achromatic Microscope, we have obtained nearly the whole of what we know of the minute structure of plants. Indeed, in no other department of science or nature has microscopic investigation been more fertile of results than in that of the vegetable kingdom. The humblest weed has had, for microscopists, an attraction unequalled by that of any other department of nature. It was by means of the microscope, that this great truth was brought to light, namely, that the life history of the individual cell is the first important basis on which to found a true physiology of the life history of plants. This fact is the starting-point of all microscopic investigations in nature. By means of the microscope, we are able to prove that disease is caused and spread by germs of minute matter floating in the air. . . . . Earth, air, water all teem with countless living forms, many of which are invisible to the unassisted eye, but, when viewed by the microscope, they exhibit the most beautiful mechanism in their framework, the most perfect regularity in their laws, and the same wondrous adaptation of parts to the creatures' wants, which furnishes proofs of the love and wisdom which so strongly mark the works of the Great Creator. . . .

'The dark abodes of unseen life are opened up for our contemplation—organisations of transcendent beauty appeal to our vision—new aspects of life, new forms of being, new laws of reproduction reward the skill of the optician, and the genius and toil of the naturalist. With wonders like these all nature is pregnant—the earth, the ocean, and the air; times past and times present now surrender their secrets to the microscope. What we know at present, even of things the most near and familiar to us, is so little, in comparison to what we know not, that there remains a boundless field for our enquiries and discoveries. And every step we take serves to enlarge our capacities, and gives us still more just and noble ideas of the power, wisdom, and goodness of God. This marvellous universe is so full of wonders, so teeming

with objects of latent beauty, that perhaps eternity alone will open up and develope sufficient opportunities to enable us to survey, admire, and appreciate them all.'

The Chairman made a few remarks upon the invaluable assistance rendered by the microscope to the study of insects, and then called upon H. Wills to read his Paper on

THE LIAS OF WHITBY.

The liassic formation consists of marine clays, shales, and limestones, abounding in shells, crinoidea, crustaceans, fishes, and extinct reptiles; with fluvio-marine beds, containing insects, minute crustaceans, lignite, trunks and leaves of coniferous trees, and cycadeous plants.

It is the lowermost group of the Oolitic system, amounting to many thousand feet in thickness, the principal litho-logical features being the uniform aspect and distinctly stratified character of its limestones and argillaceous layers; and with most constant subdivisions.

Geographical position.—The lias from the extreme north of the Yorkshire coast passes through Whitby to the south, and stretches through the rest of Yorkshire and Lincolnshire, continuing through Nottingham, Warwick, and Gloucester, and presents a remarkable regularity in breadth to within a few miles south of Gloucester, where it disperses.

Whitby is the centre of the great lias formation, which reaches in a frequently interrupted belt to the Tees, but to the south without any break as far as Robin Hood's Bay. The proximity of the Oolite is also noticeable, the very crevices in some of the lias rocks being filled up with it. The Lower Lias forms the lowest and most precipitous part, and is made up of dark blue slaty clay. The cliff consists of the Upper Lias, being friable and of a grey colour. They are both full of fossils and are exceedingly interesting, and the whole coast is rich in great Saurian remains. From the Lower Lias alum used to be extracted, whence it is called alum shale, and even now traces of it can be found. Some way along the beach or scar is the lighthouse, beyond which a very valuable fossil plant, called Equisetum or Horsetail, used to be obtained, found in an upright position as it had grown and been buried in the sand.

Reptiles.—The most striking of all the organic remains are the fossils of huge Enaliosaurs, or marine lizards, both for number, size, and structure. Of these there are two genera most remarkable—the Ichthyosaurus and the Plesiosaurus.

The Ichthyosaurus or fish lizard is not confined to the Lias, but is found in all the formations of the secondary epoch: it is evident from their paddles (long tails resembling those of a porpoise), that these animals were aquatic; their teeth and jaws show that they were carnivorous; and the half-digested remains found within their skeletons indicate the nature of their food.

Their huge size is also remarkable. I have seen one at York 30 feet long, and the average of specimens is about 20 feet. Nearly twelve species have been found.

One was found at Whitby about 5 feet long, with the greater part of the skin remaining, which is an extremely valuable discovery, helping materially to decide their nature and form.

The second Enaliosaur is called the Plesiosaurus, of which twenty species have been found. This lizard was chiefly remarkable for its huge paddles, long thin neck (in some specimens consisting of twenty-nine vertebræ), and small head; it is supposed to have lurked in the weeds and plants of the Liassic sea, and to have darted out its long neck to seize passing animals, whereas the Ichthyosaur must have had more the habits of a whale. The greatest length which I know a Plesiosaur to have attained to is 24 feet, but the average is 15 or 16 feet. It has been long agreed that these reptiles inhabited the sea, although now there is only one lizard known to be marine, found in the Galapagos Islands. In 1824 the bones of a third great reptile were dug up at Whitby, called the Teleosaurus, or crocodile, much resembling the Gavial inhabiting the Ganges. It is probable that it was an Enaliosaur, since the Gavial is known to frequent the brackish and salt waters near the river's mouth.

Fish.—The fossil fish resemble for the most part those of the Oolite, and belong to extinct genera. The remains that have caused most interest are, the large bony spines, called Ichthyodorolites, which some have supposed to be jaws and others weapons, as of the Balistes and Silurus of modern waters. But M. Agassiz, the great geologist, has proved them to be neither one nor the other, but merely the foremost spine of the dorsal fin, fixed in very strong muscles, which served to raise or depress the fin.

One of the most interesting and wonderful features of the Lias is the remarkable preservation in which the remains are found. I have seen the fossil of a cuttle-fish with the hardened ink still retained in the bag, and some vertebræ of the Plesiosaurus only partially petrified. And this again is

seen in the Coprolites or fossil excrements of the reptiles, and in the perfection of the remains.

Crinoidea.—Among the Stone Lilies or Crinoidea of the Lias the most conspicuous is the Pentacrinite. These Crinoideans are very remarkable fossils, consisting of innumerable tentacles spread in every direction, as if the animal had been floating on the top of the water, when it had suddenly been surrounded and entombed. They belonged to the class Echinodermata, and so were allied to the starfish; they fastened on a stem which was attached to a rock and there remained. Above this stem was a cup (containing the animal's viscera), from the edges of which proceeded innumerable arms branching out again and again into tentacles, which served to seize food and convey it to the mouth (situated at one side of the central cup). The animal, in life, was covered with a soft integument, which has of course decayed, and in the Encrinite the pulley screw has been left exposed, the hollow interior being filled up with lime. The starfishes found in the Lias occur principally in the middle formation, and are mostly small, with long thin arms.

The Ammonites and Nautili next come under notice. The Ammonites are principally divided into those with a dorsal keel, and those without a dorsal keel. They are extremely numerous in all the divisions of these strata, as well as in all the formations of the Secondary Epoch; but they are never found in the Tertiary except in drifted fragments. The Nautili are of the same order as the Ammonites, but are much smaller in the body. Some representatives of them are found in the seas of the present day. But of all the relics of marine animals in the deposits of the Secondary Epoch, none have excited so much curiosity and given rise to so many conjectures as to their nature and origin, as the fossils called Belemnites, vulgarly known as thunderbolts. They are mostly of a long and fusiform shape, more or less pointed at one end, and having, at the other, a conical cavity, which is either occupied by a chambered shell (called the phragmocone) or else filled up with the sand or stone in which the Belemnite happens to be embedded.

The substance of these bodies is always composed of calcareous spar, radiated in structure; they are osselets of certain cephalopods allied to the Sepia, and no doubt furnished, like those animals, with ink-bag, mandibles, large eyes, and arms bearing acetabula or suckers, although no traces of the soft parts have hitherto been discovered.

Of course the question will arise—how is it that all these live creatures were submerged and fossilised, and how is it that some were preserved in such a wonderful way? I think the best reason to give is, that they were suddenly engulfed while alive, and covered over with mud, which came down the rivers into the sea after a flood, as is frequently the case nowadays. With regard to many specimens of the Enaliosaurs, in which the head and neck and tail bones are in the natural position, while those of the body are in confusion, a very probable reason is, that the dead body floated on the water until the gases had distended it and it had become corrupted. The solid parts then falling together were still kept in a sort of bag by the tough outer skin, until it became waterlogged and sank.

Another characteristic feature of the Whitby formation is the jet. This is, in structure, closely allied to coal, and its presence can be accounted for by the vegetable remains found in the Lias.

The trees, especially conifers, are abundant. These conifers are referred to five genera, and they resemble more closely the Araucarian division than any European pines. Many, if not all of them, seem to differ from living forms in having large piths. There are other kinds of vegetable remains, such as the Sigillariæ and the Stigmariæ, the exact nature of which has not yet been determined. The flora of the Liassic age (as of the carboniferous period which it succeeded) was extremely different from that now existing. We are struck, at the first glance, by the similarity of the ferns to those now living, and the dissimilarity of almost all the other fossils except the coniferæ. Among the ferns it is not always easy to decide whether they should be placed in existing genera or not; but, in regard to most of the other contemporary forms of vegetation, it is difficult to guess their family, or even their class.

The ferns of both the Carboniferous and Liassic periods are generally found without the organs of fructification, though in a few specimens they have been well preserved. Since, however, their rarity prevents these organs being used as a basis of classification, the genera have been divided by the branching of the fronds and the arrangement of the veins.

The larger portion are supposed to have been the size of ordinary European ferns, but many show a decidedly arborescent appearance.

At the conclusion of the above Paper, W. Mogg, O.C., was proposed by C. C. Stevenson and seconded by H. Wills, as a corresponding member, but in consequence of there not being a sufficient number of members present the election was postponed to the next meeting.

Present, 58 members and visitors.

MEETING, Nov. 25, 1870.

The President in the Chair.

The Minutes of the preceding Meeting having been read and approved, Mr. Greene gave the last of his series of Papers on 'Insect Life.'

Remarking upon the means of *defence* possessed by insects in general, he observed that they might be divided into 'passive' and 'active.' Among the former might be enumerated the 'ferocious appearance' of some insects, as the stag beetle, earwig, and others; the power of simulating death, as in the case of spiders; unpleasant odours, secretions, fluids, &c. Among the passive means of defence belonging to insects, that afforded by their wonderful 'tenacity of life' was, perhaps, the most remarkable. Mr. Greene mentioned some extraordinary instances, several of which he had witnessed himself. 'Being out once on a "pupa-digging" expedition, I came to a large oak, from the trunk of which was exuding a quantity of saccharine fluid. Swarms of different kinds of insects were enjoying the feast. Among them was a huge hornet, and it was truly amusing to see the respectful way in which the various butterflies, bluebottles, &c., withdrew at the approach of their formidable companion. Emulating their caution, I drew warily near to the tree, and made a "dive" at it with my digging trowel, and succeeded in severing it at the juncture of the thorax and abdomen. Both parts immediately fell to the ground, and I went away. Returning in about half-an-hour, I found to my astonishment that the upper or thoracic part had crawled up the trunk of the tree, and was engaged as busily as ever in imbibing the sweets, apparently in no degree incommoded by the loss of his abdomen. . . . Last summer a large dragon-fly entered the cricket tent on Durdham Downs, to

the great consternation of the members assembled in it. One, more courageous than the rest, managed to knock it down, and, transfixing it with a gigantic pin, fastened it to the table. When I entered the tent, it had worked itself off the table, and was crawling about. Taking it up in my hand, I was about to remove the pin, when suddenly it flew off, and after soaring about for a moment or two in the tent, disappeared through the opening, and was seen no more. What its ultimate fate was, I know not, and it is difficult to conjecture. I may give one other instance of the tenacity of life as exhibited by a Dragon Fly. It did not come under my own notice, but the authority for it is unimpeachable. A gentleman, having captured a large specimen, cut off its long abdomen and substituted for it one made of paper, which, in some way or other, he attached to the thorax. Immediately after the completion of this severe surgical operation, the insect devoured two moderately-sized flies; whether it digested them or no, I cannot say. It then remained quiet for some little time, as if reflecting upon what had taken place; but speedily recovering itself, it soon made off, and flew away, carrying the paper tail after it with the utmost satisfaction.'

Among the 'active' means of defence were enumerated the stings of bees, wasps, and other insects; the power possessed by the famous little 'Bombardier Beetle' of emitting a puff of smoke, accompanied with, for so small an insect, a loud explosion, when pursued by its enemy, &c.

Mr. Greene then adverted to the methods employed by insects for obtaining their food. Having spoken at some length of 'Spiders,' he quoted from 'Kirby and Spence'[1] the following interesting account of the manner in which a certain species of *Myrmeleon*, commonly called the Ant Lion, obtains its food. 'When full grown (the larva), its length is about half-an-inch; in shape it has a slight resemblance to a wood-louse. . . . If we looked only at its external conformation and habits, we should be apt to conclude it one of the most helpless animals in creation. Its sole food is the juices of other insects, especially ants, but at the first view it seems impossible that it should ever secure a single meal. Not only is its pace slow, but it can walk in no other direction than *backwards*. . . . Nor would a stationary posture be more favourable, for its grim aspect would infallibly impress upon all wanderers the prudence of keeping at a

[1] *Int. Ent.* vol. i. p. 422. 1815.

respectful distance. What, then, is to become of our poor ant lion? In its appetite it is a perfect epicure, never, however great may be its hunger, deigning to taste of a carcase unless it has previously had the privilege of killing it, and *then* extracting only the finer juices. . . . It accomplishes by artifice what all its open efforts would have been unequal to. It digs in loose sand a conical pit, in the bottom of which it conceals itself, and there seizes upon the insects which, chancing to stumble over the margin, are precipitated down the sides to the centre. . . . Its first concern is to find a soil of loose, dry sand. . . . Its next step is to trace in the sand a circle. . . . This being done, it proceeds to excavate the cavity by throwing out the sand in a mode not less singular than effective. Placing itself in the inside of the circle, it thrusts the hind part of its body under the sand, and with one of its fore legs, that serves as a shovel, it charges its flat and square head with a load, which it immediately throws over the outside of the circle, with a jerk strong enough to carry it to the distance of several inches. Walking backwards, and constantly repeating the process, it soon arrives at the part of the circle from which it set out. It then traces a new one, and by a repetition of these manœuvres at length arrives at the bottom of its cavity. . . . It will readily occur, however, that to use one leg as a shovel exclusively throughout the whole of such a toilsome operation would be extremely painful and wearisome. For this difficulty our ingenious pioneer has a resource. After finishing the excavation of *one* circular furrow, it traces the next in an *opposite* direction, and thus alternately exercises each of its legs without tiring either. . . . When all obstacles are overcome, and the pit is finished, it presents itself as a conical hole about two inches deep, gradually contracting to a point at the bottom, and about three inches wide at the top. The ant lion now takes its station at the bottom of the pit, and that its gruff appearance may not scare the passengers which approach its den, covers itself with sand, all except the points of its expanded forceps. It is not long before an ant on its travels, fearing no harm, steps upon the margin of the pit. . . . The faithless sand slides from under its feet—its struggles but hasten its descent, and it is precipitated headlong into the jaws of the concealed devourer. Sometimes, however, it happens that the ant is able to stop itself midway, and with all haste scrambles up again. No sooner does the ant lion perceive this (for, being furnished with six eyes on each side of his head, he is

sufficiently sharp-sighted), than he hastily shovels loads of sand on his head and vigorously throws them up in quick succession upon the escaping insect, which, attacked by such a heavy shower from above, and treading on so unstable a path, is almost inevitably carried to the bottom. . . . The dry carcase he subsequently jerks out of his den, that it may not encumber him in future contests, or betray the "horrid secrets of his prison house," and if the sides of the pit have received any damage, he leaves his concealment for a while to repair it, which being done, he resumes his station.'

Mr. Greene had hoped to have made observations upon the 'injuries,' direct, indirect, personal, &c. inflicted by insects, but the time having expired, he expressed a hope that he might be able to do so on some future occasion, and concluded his paper with an anecdote from Kirby and Spence respecting a very familiar little insect. 'An amusing anecdote is told of one of these exhibitions (industrious fleas). A sovereign of one of the petty German states having commanded the attendance of one of these exhibitions, the performance commenced. Some were harnessed like horses, others dressed up to represent celebrated characters, as Napoleon, Wellington, &c. But soon the exhibitor became perturbed, looked here and there, searched his repository, and at length stopped the performance, exclaiming, "Where is my Napoleon?" Search was made, but in vain. "Where can he be gone?" asked the King. The exhibitor looked uneasy, but said nothing. "Tell me," said His Majesty, "what you suspect." "If I may be so bold," replied the exhibitor, "I suspect that it has taken refuge with the Princess H." "Then," said the King, "search shall be made," and the Princess retired. After a while she appeared with the captive, and it was put on the stage; but, alas! the exhibitor suddenly exclaimed, "It is not my *Napoleon*! it is a *wild one*!"'

In the unavoidable absence of J. F. M. H. Stone, a Paper by him on 'Dragons' was read by J. Allen.

DRAGONS.

In endeavouring to investigate the history of Dragons, I find myself limited in every source to which I have applied myself. I have found some clue to their actual existence in those fabulous accounts attributing so much of the marvellous to those real or imaginary monsters of sea and land which we have been accustomed (happily exempted as we are from their

presence in whatever form) to think of with dread and horror as surpassingly formidable.

There are four sources by which we can endeavour, though without any absolute certainty (except in the two last) to define the true characters of this wonderful animal: these are sacred and profane history, geology, and natural history. Dragon, in Scripture, is a word which answers generally to Hebrew words—*tan*, *tannin*, *tannim*—as in Genesis, chap. i. verse 21, 'And God created great whales.' Job says: 'I am a brother to dragons, and a companion to owls.' Cities reduced to desolation are often described by the prophets as dens or dwelling-places for dragons; as in Jeremiah, chap. li. verse 37: 'And Babylon shall become heaps, a dwelling-place for dragons.' The prophet Isaiah, foretelling the cities that should be laid waste by the Edomites for joining with the Chaldeans against the Israelites, says: 'And in her palaces shall come up thorns, nettles, and brambles in the fortresses thereof: and it shall be an habitation of dragons.'

The fabulous history of St. George and the dragon is founded upon the persecution of Christians by Diocletian. St. George is said to have complained of his severities towards them, for which he was imprisoned and beheaded A.D. 290. Diocletian was represented as the dragon, with St. George, the champion of the faith, thrusting his lance into the persecuting monster's side. But in fable and fiction, as well as tradition, wherever there is much error there is generally some amount of truth, out of which valuable facts may be elicited. Dragons' heads and dragons' tails are astronomical terms to denote the nodes of the moon and planets, as also a constellation of the northern heavens, representing the monster which guarded the garden of the Hesperides.

The dragon of Geology is to be sought in the Saurians (a term taken from the Greek '*σαύρα*,' a lizard). Many fossil skeletons of these strange reptiles have been found, some of enormous length, the oldest in the lower part of the secondary strata. Some of the known species of Ichthyosaurus must have exceeded thirty feet in length; and, according to Dr. Buckland, their eyes were sometimes larger than a man's head. The saurians appear to have been in part marine; others were amphibious, others terrestrial, and some were capable of flying. By far the most interesting of them is the Pterodactyl, or flying dragon, of which Cuvier says, that of all the forms whose ancient existence has been revealed to us, these flying reptiles are incontestibly the most extra-

ordinary, and such as if now living would appear most at variance with any animal now endowed with life. For these ancient flying dragons did not sustain themselves in the air by means of their ribs (as the *Draco volans* of India does at the present day), nor by a wing like that of a bird, nor like that of a bat, but by a membrane upheld principally on a very elongated 'little' finger, whilst the other fingers preserved their ordinary dimensions and their claws. Well may Cuvier declare that to those who had not followed out the details of its structure, a representation of the animal as it formerly breathed and moved, would appear more like the offspring of a disordered imagination than of the ordinary powers of nature.

We often see 'dragons' represented with wings, not like those of birds, but resembling bats. Among the kinds of serpents mentioned in Scripture are those fiery flying serpents that made so great a destruction among the Israelites, and were the death of so many people in the desert. The Hebrew word here used for serpents is *saraph*, which properly signifies *to burn*; and it is thought that this name was given to them either because of their colour, or because of the heat and thirst they created by their bitings. Herodotus, who says that he had seen these serpents, tells us they had great resemblance to those animals called by both the Greeks and Latins *hydræ*, the destruction of which constituted one of the labours of Hercules. The same old writer informs us that he went on purpose to the city of Butus to see those flying serpents of which he had often previously heard. He found near this city great heaps of bones, and the spines of those animals that had been killed and devoured by the Ibis. 'The place,' says he, 'is a narrow neck of ground that widens towards Egypt. When, therefore, at the beginning of spring, these serpents come out of Arabia into Egypt, the Ibis attacks them, and destroys great numbers of them.' The wings of these serpents, he says, are membranes like those of bats. He also adds, that they are not of large size, and that they are speckled or of several colours, and are found in such large quantities in Arabia, that the inhabitants could not exist by reason of their ravages, if Providence had allowed them to multiply according to the usual laws of nature. The female, however, says he, puts the male to death; the young ones kill their mother, and thus their numbers became greatly restricted. It is not unlikely that some of the fabulous accounts about the dragon may have been based upon the curious little animal called the Flying Dragon (*Draco*

volans). It is a small lizard, found in the jungles of India, whose abdominal ribs are greatly extended and covered with membrane. The animal is quite destitute of any power to strike the air, so that its flight is in fact nothing but a mere floating, like the fall of a parachute. These real dragons are perfectly harmless creatures and can be handled with impunity. Their food consists of insects, and they are only a few inches in length.

Two Hamburg merchants, about 1734, gave out that they possessed a wonderful dragon, which, from the description given of it, must have been a frightful monster. It was on sale for ten thousand francs, but it seems that no one could make up his mind to give such a high price. One day in walked a foreigner, to whom the precious specimen was shown. The foreigner was Linnæus. He was asked what he thought of it? The great naturalist carefully examined the dragon, and appeared to be lost in admiration. He was then asked a second time, and he replied, that it was wonderful—very; and a most ingenious combination of snake skins, teeth of weasels, claws of birds, &c. Linnæus was threatened with a prosecution for injuring the merchants' property, and it is said that he left Hamburg as soon as he could, to avoid their anger.

I shall here mention some remarkable facts in reference to snakes, ancient and modern. Such universal antipathy has been at all times felt towards these repulsive creatures that it is no wonder they have been imported into the structure of the legendary dragon, almost invariably represented with a forked tongue, huge jaws, a long scaly body, and a coiled tail which could be easily enough matched in the Python or Boa of our own day. Indeed, but for the huge wings and sprawling legs of the monster of romance, the great serpent of real life might be well set down as its modern representative, so like is it in structure and so similar in its voracious habits.

The largest serpent on record is that mentioned by Livy and Pliny, which opposed the Roman army, under Regulus, at the river Bagrada in Africa. It devoured several of the soldiers, and so hard were its scales, that they resisted darts and spears; at length it was, as it were, besieged and the military engines employed against it as against a fortified city. It is said to have been one hundred and twenty feet in length. The skin was sent to Rome, where it was suspended in a temple and remained for many years.

At Batavia was taken a serpent, which had swallowed an

entire stag of a large size; and one taken at Bunda is reported, in like manner, to have swallowed a negro woman. It is said that Ahisaumis, an Indian prince, had two serpents—the one two hundred and ten feet long, and the other one hundred and twenty feet. Suetonius, in the forty-third chapter of the 'Lives of the Twelve Cæsars,' mentions that the emperor Augustus, over and above the regular shows, exhibited a snake seventy feet long.

For the accuracy of the following story I can vouch. Mr. Edwin, a resident in India, saw a serpent in the island of Ceylon that measured thirty feet four inches. It was covered with scales, ridged in the middle. Its head was green with large black spots in the middle, yellow streaks around the jaws, a yellow circle, like a golden collar, around the neck, and behind that was another black spot. Its head was flattish and broad; its eyes monstrously large, and very bright and terrible. Its sides were of a dusky olive colour. Its back was very beautiful; a broad streak of black curled and wavered at the sides, running along it; on the edges of this appeared a narrow streak of a fleshy colour, and outside there was a broad streak of bright yellow, spotted at short distances with long blotches of a blood colour. It had perched itself on a large palm-tree. As a jackal passed by, it darted down upon the unfortunate animal, and in a few minutes sucked him into its belly. Next morning a monstrous tiger, about the height of a heifer, passing by, the serpent again darted down, seized him by the back, and twined itself three or four times around his body. It then loosed its teeth, and grasped the tiger by the head, tearing and grinding, and shaking him all at once, while the assaulted animal, in its fury, kept resisting to the utmost. Finding the victory no easy one, and the tiger's bones not readily to be broken by mere tail-winding on the serpent's part, it dragged the victim to a tree, and there setting him against it, turned itself round both him and the tree, and crushed him so completely that his ribs, the bones of his legs, and at last even his skull, were broken and bruised. After it had killed the tiger with this inexpressible torture, extending over almost an entire day, it covered the body with saliva till it became like a lump of red flesh, and at last, with a labour of some hours, sucked up the whole carcase into its capacious interior; while in this gorged state, Mr. Edwin and his companions killed it with clubs.

I have introduced these anecdotes about Boas, because they bear, I think, a close resemblance to the mythical tales

told of the dragon. I feel sure that any person with an exaggerative turn of mind, inclined to the marvellous, could mould them in his memory into such a shape as would be very like those of the ancient dragons. And so, those old tales may be traced back to ornamented accounts of large snakes, represented with all the paraphernalia of wings, feet, and poisonous breath, which lent so many horrors to the dreaded monster

Dragon-flies are well named, on account of the ferocious look displayed by their jaws; but badly on account of their elegant wings and body, for we can never suppose dragons to have possessed such slender and well-shaped appendages as these flies. The ancient mythical flying dragons, with their thick and heavy bodies, could only have flown very low and clumsily, and the flight could not be compared to that of the graceful dragon-fly, which we see in summer darting along the hedge-rows, then suddenly turning, and sweeping back so swiftly that the eye can scarcely follow it in its aërial evolutions.

The hand of Providence is apparent in adjusting the balance of creatures. As the earth can afford room and support to only relative proportions of carnivorous animals, if they should multiply beyond proper bounds, they must of necessity feed on one another. To keep the balance equal, Providence has limited the lives of all creatures to definite lengths, and their increase to such a number as is proportionate to their use in the world. It is therefore evident, that if human beings ceased to multiply in a proportionate ratio, the brute creation must soon preponderate and exceed the appointed limits.

Even with animals that are apparently injurious to man, a balance of power seems requisite. At Singapore, the planters have found that the killing of tigers has been attended by the greater pest of an increase of wild hogs, which destroyed the crops. One English planter has therefore become a protector of tigers. Creatures, too, which are useful and serviceable to man, abound more than those which are hurtful. There are no herds of lions as there are of oxen; no flocks of tigers as there are of sheep. The flying dragons have been succeeded by birds; Ichthyosaurus, Plesiosaurus, and the like, by whales, dolphins, and great fishes. Instead of the Iguanodon, the ox, deer, and the sheep quietly crop the verdant herbage, whilst in place of the destructive Megalosaur, the carnivorous mammalia keep down the excessive multiplication of ruminantia, and man has the

dominion over all. In future ages his remains will fill the bosom of the earth, and the traveller in some far distant century will gaze with wonder and amazement at the fossil relics of what was once Man.

At the conclusion of the meeting, the President stated that he had received the Transactions of the Natural History Societies of Rugby, Harrow, and Marlborough. He remarked upon the good attendance at the Clifton College meetings, as compared with that of other schools, and expressed a hope that members intending to give Papers would endeavour, as far as possible, that they should be original matter.

A Ballot was then held, and W. Mogg, O.C., who had been proposed and seconded at the previous meeting, was declared to be duly elected a Corresponding Member.

Present, 58 members and visitors.

MEETING, December 17, 1870.

The President in the Chair.

This was the last meeting both of the Term and the Year, and was held chiefly for the purpose of electing the Officers for the ensuing Term, in 1871. Before this was done, W. J. P. Wood read a paper, illustrated with experiments, upon the 'Electric Telegraph.'

Commencing with a few words on Telegraphy in general, and on the telegraphs used by our forefathers, he showed next how an Electric Telegraph, to be worked by Static Electricity, was proposed soon after the invention of the Frictional Machine. The effect of an electric current on the Galvanometer, or suspended magnetic needle, was then explained, and illustrated experimentally. The separate parts of an ordinary Cooke and Wheatstone's instrument were considered one by one, and details added as to their construction; the different forms of the battery used on different lines forming a distinct feature in the paper. One of the telegraphs placed on the lecture table was then removed into an adjoining room, and a conversation carried on between the

two stations. While these arrangements were in preparation, the Alphabet was discussed, attention being chiefly given to the single Needle Code. The instruments used in the present Atlantic Telegraph were explained, including the Cable and the reflecting Galvanometer, the writer concluding an interesting and instructive paper with the remark, that the subject last referred to was of so extensive a nature, that he could not enter more particularly into it on that occasion.

At the close of this paper visitors withdrew, and the Society entered upon the transaction of its private business. The five following gentlemen were elected Honorary Members:—

Rev. Canon Moseley, M.A. F. Black, Esq., M.D.
Joshua Saunders, Esq. [1]J. A. Symonds, Esq., M.D.,
F. F. Tuckett, Esq. F.R.S.E.

It was proposed by the President that a Sub-committee should be appointed for the purpose of editing the Report of the Society's Transactions. The motion being carried, the following were proposed and elected to form the Committee.

M. J. B. Ward (President), T. H. Warren,
Rev. J. Greene, W. J. P. Wood.
J. F. M. H. Stone,

The Society then proceeded to the election of its Officers, that of 'President' being the first. Previous to any names being proposed for this office, the Rev. J. Greene rose and suggested to the members that, so long as the Society possessed so able and suitable a President as Mr. Ward, he should be requested then and hereafter to hold that post, without the formality of any election. This was carried unanimously and with acclamation.

The Rev. J. Greene was re-elected Treasurer.

From a large number of candidates for seats on the Committee, the four following were chosen:—

J. F. M. H. Stone, T. H. Warren,
R. F. Brunskill, R. W. Wilson.

The Committee subsequently elected J. F. M. H. Stone as Secretary.

[1] The lamented death of Dr. Symonds took place but shortly afterwards, February 25, 1871.

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Bird, A.	0	5	0			
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Boyd, S. A.	0	1	6	0	7	6
Boyle, C.	0	10	0			
Brinkley, J.	0	5	0	0	7	6
Brittan, C. J.	0	2	6	0	6	0
Brittan, E. B.	0	2	0	0	6	0
Brodie, E.	0	5	0	0	7	6
Brown, Rev. T. E.	2	2	0	1	0	0
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Risdon, —	0	10	0	0	7	6
Ritchie, —		—		0	15	0
Robertson, R. G.	0	5	0			
Robinson, —	1	0	0			
Robinson, —	0	15	0	0	7	6
Robson, A., Esq.	2	2	0	1	0	0
Rodwell, G. F., Esq.	1	1	0	0	10	0
Routh, J.	0	5	0	0	7	6
Rücker, R.	0	5	0	0	7	6
Rundall, Mrs.	1	0	0	0	10	0
Saunders, T. B., Esq.	1	0	0			
Saunders, T., Esq.		—		0	6	0
Saunders, Mrs. T. B.	1	0	0			
Saunders, —	0	10	0	0	7	6
Saunders, —	0	5	0	0	7	6
Saunders, E. R.	0	5	0			
Saville, —	0	5	0	0	7	6
Savory, —		—		1	1	0
Scott, —		—		0	15	0
Scott, —		—		0	7	6
Shaen, W., Esq.	3	3	0			
Shaen, A.	0	5	0			
Shaw, W., Esq.	0	10	6			
Shepperson, A. F., Esq.		—		1	10	0
Smith, W., Esq.		—		0	10	6
Smith, E.	0	2	6			
Smith, —	0	5	0	0	7	6
Smith, J. A.		—		0	5	3
Smith, G.		—		0	5	3
Smith, —	0	5	0			
Smyth, G. H.	0	5	0			
Smyth, W. S.	0	5	0			
Spicer, P. E.	0	5	0	0	7	6
Stevenson, C. C.	0	5	0	0	7	6
Stewart, —	0	10	0	0	7	6
Stodart, —	0	5	0	0	7	6
Stodart, —		—		0	7	6
Stodart, —		—		1	10	0
Stone, J., Esq.		—		1	1	0
Stone, H. C.	0	5	0	0	7	6
Stone, J. F. M. H.	0	10	0	0	7	6
Strachan, —	0	2	6			
Strachan, —		—		0	4	6
Strange, —	0	5	0	0	15	0
Sturgess, —		—		0	9	0
Sturgess, —		—		0	9	0
Stutfield, —	0	5	0			
Sumner, —	0	5	0			
Sumner, —		—		0	10	0
Sumner, —	0	5	0	0	7	6
Tatham, —		—		1	0	0
Tatham, —	0	5	0	0	7	6
Tebbs, —	0	5	0	0	7	6
Thatcher, Mrs.	0	10	0			
Thatcher, —		—		0	7	6
Thurtell, A., Esq.	1	1	0	0	10	0
Trimnell, W. F., Esq.	1	1	0			
Turnbull, G., Esq.	5	0	0	0	10	0
Twist, T. K., Esq.	5	0	0			
Twist, —		—		1	10	0
Tyler, —		—		1	10	0
Vicary, J., Esq.	5	0	0			
Walton, —	0	3	6	0	9	0
Walton, —		—		0	15	0
Walton, —	0	2	0			
Ward, M. J. B., Esq.	1	1	0	0	10	6
Ward, M. J.		—		1	1	0

	Donations			Subscriptions		
	£	s.	d.	£	s.	d.
Warden, — . .	0	10	0	0	15	0
Warren, T. H. .		—		0	15	0
Warren, S. H.. .		—		0	7	6
Warren, E. P. .		—		0	7	6
Washbourne, — .	0	5	0	0	7	6
Washbourne, — .	0	5	0	0	7	6
Wetherman, — .	0	5	0	0	7	6
Wileman, — . .	0	5	0			
Williams, — . .		—		0	15	0
Williams, — . .		—		1	1	0
Williams, — . .		—		1	10	0
Williams, — . .	0	5	0			
Wills, G., Esq. .	5	0	0			
Wills, H. . .		—		0	10	0
Wilson, C. . .	0	5	0			
Wilson, J., Esq. .	1	0	0			
Wilson, R. W. .	0	5	0	0	7	6
Wilson, — . .	0	5	0	0	7	6
Winter, W. . .	0	5	0	0	7	6
Wintle, J., Esq. .	2	2	0			
Wiseman, Rev. H. J.		—		0	10	6
Woodburn, Mrs. .	1	1	0	0	10	6
Woodhouse, — .	0	5	0			
Woodhouse, Mrs. .		—		0	10	6
Woodley, — . .		—		1	1	0

NOTE.—Although great care has been taken, it is feared that there are many inaccuracies in this list. The Treasurer to the Fund (Mr. Barrington-Ward) will gladly rectify any omissions or errors if they are reported to him. A statement of accounts will appear in the next Part.

Circulars have been issued, giving details of the scheme, and copies of them (as well as forms of subscription) may be had on application to the Treasurer. A considerable sum is still required to carry out the plans fully.

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LONDON: PRINTED BY
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With the President's compliments

22nd March 1872

TRANSACTIONS

OF

THE CLIFTON COLLEGE

Scientific Society

FOUNDED JUNE 25, 1869

"VIRESQUE ACQUIRIT EUNDO."—Virg. *Æn.* iv. 175

IRISH MUSEUM
NATURAL HISTORY

PART II.

CLIFTON
J. BAKER & SON, MALL PLACE
T. KERSLAKE & CO., ROYAL PROMENADE
AND AT THE SECRETARY'S OFFICE, CLIFTON COLLEGE
1872

PRICE HALF-A-CROWN

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1872

PREFACE.

It is with considerable pleasure that we are able to lay before the members of the Clifton College Scientific Society the second Part of its Transactions. Six months only have elapsed since the issue of the First Part, but the reception accorded to the new publication has been so favourable, and the subsequent proceedings of the Society so interesting, that we feel sure no apology is needed for the production of another record of the progress of science amongst the boys of Clifton. The past half-year has been especially noted by the long-expected opening of the new Museum and Botanic Garden. This event was made the occasion for an exceedingly agreeable and successful conversazione, which will not readily be forgotten by those who had the pleasure of attending it. We have given as full an account of the proceedings as our space permitted. It is pleasant to be able to add that the Museum and Garden thus inaugurated are already well-stocked and in good working order, while the use made of the collections, and the evident interest manifested in them throughout the College, seem abundantly to justify their formation.

The papers read at the Society's meetings have been as numerous as previously, and the attendance of members and visitors has in no degree fallen off. There is still much to be

desired, however, on one point. Too many members are content to be *listeners* only, and the real work of the Society rests on comparatively a few. This seems hardly fair, and its continuance will not tend to permanent success. In such a body as ours all ought to work, and there is plenty for every one to do if he likes to do it. But it is only right to say that the number of working members is steadily increasing; for the "compulsory attendance clause" is gradually driving away those who only look on scientific meetings as a lounge to pass an idle hour, and the seats vacated are speedily filled by more profitable adherents. An indication of the present popularity of the Society is shown in the fact, that at a recent election of members, no fewer than twenty-one candidates appeared for five places.

The Sections have hardly been established long enough to enable us to say much as to their bearing on the Society at large. At present they must be viewed as experiments rather than settled institutions. But there is a considerable interest taken in most of them, for nearly all have the full complement of membership; and if the Directors are only true to their duties, these Sections can hardly fail to be most valuable adjuncts for the scientific advancement of the younger members especially, and must contribute much to the general utility of the Society. A few words will suffice to show the state of work in each of them.

BOTANY.

Excursions have usually been made once or twice a week, and they have been well attended. The Director is engaged in preparing a flora of Clifton, and several hundred notices of the stations of plants and dates of flowering have been recorded. In this work he has met with great assistance from many boys wholly unconnected with the Society —especially among those of the Junior School. The Herbarium is in good condition, and it already includes specimens of most of the British flowering plants. The competition for the Natural History medals brought in several botanical contributions, and two medals fell to the

share of members of this Section (W. B. Ffooks and M. J. Ward). Evening meetings will be held during the winter, for the use of the microscope.

ZOOLOGY.

Very little has as yet been done. The collection of Birds' Eggs in the Museum has been carefully arranged and labelled, and a typical series of zoological specimens has been commenced.

ENTOMOLOGY.

Some meetings have been held, and a large number of insects (principally Lepidoptera) have been collected and bred by various members, the Director assisting in the determination of species and habitat, when necessary. As will be seen in another place, the Society's cabinet of Lepidoptera has been placed in the Museum, and it is much used for study and reference. Professor Westwood's valuable donation of Coleoptera ought also to be mentioned, as one which will be of considerable use to this Section. A silver medal for a fine collection of insects, made during one term, was gained by J. Stone, the Secretary of the Society.

GEOLOGY.

The Geological Section has held a good many meetings; has made expeditions to Cheddar, Portishead, Aust, Bedminster, Providence Iron Mine, and other places in the vicinity; and has collected a considerable number of specimens from the carboniferous limestone and lias. These are being arranged in the Museum, as the nucleus of a local series.

ARCHÆOLOGY.

The arrangement of the coins in the College Museum has been taken in hand, and a considerable number have already been placed in the drawers. Some architectural visits and investigations have been planned, but are as yet unattempted. Summer term had so many counter attractions for Cliftonians that antiquarian zeal has languished sadly during the long fine weather, but we hope to do something for our reputation in the winter months.

CHEMISTRY.

This Section has been languid in the extreme. Several members, in common with some from the Physical Section, made the spectrum their special study during term, with a view to competing for the prize offered to the two Sections. It was won by W. A. Smith, but the competition

was so close that Mr Norman Lockyer (the examiner), himself gave a second prize to C. T. Blanshard, while D. H. Walsh obtained honourable mention.

PHYSICS.

Unsatisfactory. Meetings few and not well attended. The Director will require to use his strongest efforts to infuse some life into that which *ought* to be an important section. Barometric observations have been made regularly by W. B. Ffooks with the fine barometer so kindly given to the Society by Mr Tuckett.

When a little more time has elapsed, we expect to be able to give better reports than these. We are very hopeful that the Sectional work will ultimately become perhaps the most important portion of the Society's operations, though it is found to be a difficult matter, in a busy, hard-working school like ours, to devote to any *one* branch of science that amount of time and attention so necessary for its minute study.

The Museum and Botanic Garden Fund has had liberal contributions, yet the expenses have been so heavy that the balance on hand is now only a small one. The contracts for the erection of Museum cases and the laying out of the Garden necessarily involved a large expenditure at the outset, but less money will be hereafter required, for the means of *maintaining* both institutions need now alone be provided. To this Fund most members of the Scientific Society have subscribed, and many other Cliftonians as well, while a considerable number of parents authorise the charging of a small sum terminally in the School accounts on behalf of the Fund. It is to be hoped that those who may hereafter become connected with the School will assist in keeping up the Garden and Museum by their subscriptions, seeing that both of them are entirely dependent on the voluntary support of those who may from time to time take a special interest in the success of the College.

The Curator of the Museum and Garden has furnished a

detailed report of the progress made in each department, and it will be seen from this document (which we have inserted), how much has been done, in a short time, towards the formation of the various collections. The Scientific Society's books have been allotted a special place in the College Library (which at present occupies an apartment in common with the Museum), and a portion of the Museum Fund has been wisely expended in the purchase of valuable works for scientific reference. All these books are at the service of those who desire to study in the Museum.

The best thanks of the Society are due to Mr Lovell Squire, who came from Cornwall, at an inclement season of the year, to read a paper before our members. Mr Squire's interesting communication will be found in the present volume. Several other scientific gentlemen have promised to give us lectures during the coming winter.

There have been, as may always be expected in a School Society, many changes amongst our members lately, and some of the most valuable of our adherents have gone forth into the busy world, leaving Clifton for ever. It is, however, gratifying to find in many cases that we are not forgotten, but that pleasant recollections of the scientific evenings are cherished by those whose school-days are now numbered among things of the past. Old Cliftonians have sent us again and again kindly wishes for our success, and many a donation from them appears in our Museum.

This Society may not, perhaps, be destined to achieve much triumph in scientific discovery and observation, nor, from the nature of the case, could it well be expected that those who are, for the most part, mere tyros in science should emulate in their works savants of greater experience and riper years. But if it should serve to awaken a keen interest in the great truths which science has brought to light, and should thereby be the means of turning into paths of profit and pleasure some who,

but for it, would never have entered them; if, again, it should perform the humbler, though no less valuable, mission of bringing together in the delightful study of nature those whose kindred tastes and frequent association may lead to many a happy reminiscence of early days and many a lasting friendship—then surely the CLIFTON COLLEGE SCIENTIFIC SOCIETY will not have been founded in vain.

M. J. B. W.
J. F. M. H. S.

December 1871.

LIST OF MEMBERS.

PRESIDENT.

M. J. BARRINGTON-WARD, B.A., S.C.L., F.R.G.S., F.L.S.

SECRETARY.

J. F. M. H. STONE.

TREASURER.

R. F. BRUNSKILL.

COMMITTEE.

REV. J. GREENE, M.A., M.E.S.
T. H. WARREN.
R. B. DON.
D. PEARCE.

HONORARY MEMBERS.

REV. J. PERCIVAL, M.A. (Head Master)
REV. H. J. WISEMAN, M.A.
REV. H. C. WATSON, M.A., F.R.A.S.
C. J. PEILE, B.A.
G. F. RODWELL, F.R.A.S., F.C.S.
REV. B. HARTNELL, M.A.
G. T. ATKINSON, B.A., F.C.S.
REV. CANON MOSELEY, M.A.
T. PROCTOR, Esq.
J. SAUNDERS, Esq.
F. F. TUCKETT, Esq., F.R.G.S.
F. BLACK, Esq., M.D.
J. G. GRENFELL, B.A.
J. PERRY, B.E.
REV. H. N. ELLACOMBE, M.A.
REV. E. HARRIS, M.A.
REV. R. B. POOLE, M.A.
J. ROBINSON, F.C.S.
REV. C. KINGSLEY, M.A., F.R.S.
PROF. M. LAWSON, M.A., F.L.S.

CORRESPONDING MEMBERS.

A. CRUTTWELL, Cardiff.
E. O. ASHBY, Merton Coll., Oxford.
W. F. HOWLETT, Christ Ch., Oxford.
F. W. SHAW, Chorley New Road, Bolton-le-Moors.
A. W. BRODIE, Sid. Suss. Coll., Cambridge.
H. H. MOGG, Pemb. Coll., Cambridge.
J. I. FOX, Trinity Coll., Dublin.
H. PROCTOR, Univ. Coll., Oxford.
C. T. BLANSHARD, Queen's Coll., Oxford.

ORDINARY MEMBERS.

ADEY, W. M.
ALLEN, J.
ANDERSON, R.
ASPLAND, W. G.
BAILLIE, W.
BATCHELOR, A. E.
BELL, J.
BONHAM-CARTER, L.
BROWN, H. R. F.
BROWNLOW, C. B.
BUSH, J. P.
CHITTY, J. S. W.
CLAXTON, W.
CLARK, W.
CLERK, H. E.

Cole-Hamilton, A.
Crosse, E.
Dakyns, G.
Darley, A. E.
Darling, W.
Druitt, W.
Duncuft, J.
Evans, A.
Forbes, J.
Fowler, H.
Fuller, L.
Gibbons, J.
Greene, A. D.
Heath, A.
Heath, H. N. C.
Hewson, J. J.
Jenkins, T. L.
Key, J.
Leonard, A. G.
Leonard, W. G.
Le Strange, G. S.
Locke, G.
Maw, G.
Maw, M. H.
Moggridge, J. A.
Ogle, P. R.
Ogilvie, P.
Oliphant, W.
Powell, F. D. H.
Prinsep, J. C.
Rankin, T.
Richardson, R.
Saunders, F. T.
Saunders, H. J.
Savile, W.
Smith, W. A.
Smyth, G. H.
Stevenson, C. C.
Stodart, G.
Stone, H. C.
Sumner, R.
Swinburne, J.
Tebbs, L.
Vaughan, J.
Vickers, H. O.
Walsh, D. H.
Ward, M. J.
Warden, F.
Warren, A.
Wedderburn, E. K.
Wills, H.
Wood, W. J. P.
Woodforde, L. B.
Woodforde, W. B.

MEMBERS WHO HAVE LEFT THE SCHOOL SINCE LAST TERM.

Berrington, A. J.
Blanshard, C. T.
Evill, W. E.
Heath, J.
Heath, J. B.
M'Corquodale, G. F.
Murray, R. L.
Penney, F. L.
Penny, C. S.
Tyler, C.
Wilson, R. W.

DIRECTORS OF SECTIONS.

Archæology { J. C. Prinsep. / *R. W. Wilson.*
Botany..... { G. Dakyns. / *M. J. Barrington-Ward.*
Chemistry... { W. Robinson, F.C.S. / *W. A. Smith.*
Entomology...Rev. J. Greene, M.A.
Geology.....J. G. Grenfell, B.A.
Physics..... { W. A. Smith. / *W. J. P. Wood.*
Zoology..... { D. Pearce. / *J. F. M. H. Stone.*

☞ *The names of Directors who have retired are printed in italics.*

RULES.

I.—That this Society be called the 'CLIFTON COLLEGE SCIENTIFIC SOCIETY.'

Constitution.

II.—That the Society consist of Ordinary, Corresponding, and Honorary Members.

Officers.

III.—That the Officers of the Society consist of a President, Secretary, Treasurer, and three Members of Committee, to be elected from and by Members of the Society, with the exception of the Secretary, who shall be chosen by the Committee from their own number. All Officers, excepting the President, to be elected terminally.

Management.

IV.—That the affairs of the Society shall be conducted by the above Officers.

Secretary.

V.—That the duties of the Secretary be, to keep a list of all the Members of the Society, and of all former Members and Benefactors, who may wish to receive the Transactions of the Society; to give notice of meetings, and to keep a detailed report of the proceedings, as well as lists of Members and Visitors present at each meeting. In the absence of the Secretary, the President may appoint any Member of the Committee to take minutes of the proceedings.

Treasurer.

VI.—That the duties of the Treasurer be, to collect all sums of money due to the Society, to receive all donations of money, and to disburse all sums of money payable by the Society out of the funds intrusted to him.

That the Treasurer furnish terminally a detailed account of the receipts and disbursements, to be audited by the Committee.

Members.

VII.—That the number of Ordinary Members be seventy, of whom ten shall be elected from the Junior School.

That Ordinary and Corresponding Members shall be elected by the Society, but that all names of candidates must be given to the Secretary (not later than the day previous) for insertion on the notice of meeting.

That those candidates for Ordinary Membership who shall receive the highest number of votes shall be elected, according to the number of vacancies.

That, on election, every Member of the Society shall sign his name in a Register (to be kept by the Secretary).

That Honorary Members shall be elected by the Committee, and shall be entitled to receive the Transactions of the Society on payment of a single sum of Half-a-Guinea.

That a subscription be payable terminally by all Ordinary Members (the amount to be fixed by the Committee), but in no case to exceed Two Shillings and Sixpence for the Upper, and Two Shillings for the Junior School.

That Honorary Members residing at the College shall have all the privileges of Ordinary Members.

That all subscriptions must be paid between the first and second meetings of the term, and that any member retiring from the Society be required to pay all subscriptions due.

That, under penalty of expulsion from the Society, all Ordinary Members be required to attend two-thirds of the meetings in each term, except for reasons deemed sufficient by the President.

That Corresponding Members shall have the privilege of taking part in the proceedings of all meetings that they may attend, but shall not be liable to any subscription.

Sections.

VIII.—That Sections be formed for the more accurate study of the different branches of science, and that the Directors of these Sections be chosen terminally by the Society.

That the Sections shall hold meetings as often as may seem fit to their respective Directors, at which any Members of the College, with the sanction of the Director, may attend.

That the Directors of the different Sections be invited to communicate to the Society any matters of interest which may have come before them, and that such communications be made at the commencement of each public meeting, at least one day's notice having been given to the Secretary.

That reports of the work done in each Section shall be handed by the Directors to the President before the final meeting of every term.

That the President and Secretary be *ex officio* Members of every Section, and shall receive notice of all sectional meetings.

That not more than ten Members be permitted to join any one Section.

That all elections in each of the Sections be vested in its Director, who may, at his discretion, remove any Member from it, subject only to the approval of the President.

That there shall be seven Sections: BOTANY, ZOOLOGY, CHEMISTRY, PHYSICS, ENTOMOLOGY, GEOLOGY, and ARCHÆOLOGY.

Meetings.

IX.—That ordinary Meetings of the Society be held at least once a fortnight during term, but that the President be empowered to call extraordinary Meetings and to postpone the regular Meetings.

That twenty Members shall form a Quorum.

That the order of business at each Meeting shall be arranged by the President.

That Members be requested to bring for exhibition at the Meetings of the Society, specimens of Natural History and illustrations of Natural and Physical Science in general.

That Members be invited, when they may have it in their power, to present donations and specimens to the College Museum, such donations to be acknowledged at the Meetings, and in the Society's Transactions.

That in all cases of equality in voting, the President shall have a casting vote.

New Rules.

X.—That any Member of the Society have power to propose any new rule, or any alteration in an old one, provided the motion be seconded by another Member, and that notice of at least one week be given to the Secretary.

TRANSACTIONS

OF THE

CLIFTON COLLEGE SCIENTIFIC SOCIETY.

MEETING, Feb. 10, 1871.

The President in the Chair.

The first meeting for the term and year was held on 10th February, in the Physical Lecture-room. Fifty-nine members and visitors were present. The minutes having been read by the Secretary, and passed, the President delivered an opening address, of which the following is an abstract:—

He said they were met that evening to inaugurate a new session of the Clifton College Scientific Society, and he congratulated the members on the vigorous way in which they had already set to work. He hoped they were determined not to let their zeal languish, but that they would make the coming session the precursor of a long series of successes for the Society, and a season of no inconsiderable pleasure and improvement for themselves.

Dating their sessions by terms, and not by years (as in most associations of the kind), the President thought it could hardly be expected that he should deliver a long 'inaugural address' at the commencement of each of those short periods. He did not intend, therefore, to ask their attention that evening for more than a few minutes, and he thought it would be better if he were to confine his few observations to some topics connected with the working and the prospects of the Society. He thanked them very sincerely for the honour they had done him in electing him

once more as their President. He felt really proud of that distinction, of which he was so unworthy a recipient. It was always a real privilege to preside over any body formed for the furtherance of knowledge; but when that body was blessed with the vigorous health and growth which promised to its youth a robust manhood and a sound constitution; when again it was—as he hoped this was—an association of willing learners, and enthusiastic lovers of all that was good, and beautiful, and true,—then did the Presidential office become one of great responsibility, and many a conscientious man, however competent, would shrink from the acceptance of its duties. For his own part, he would rather have occupied a mere ordinary place among the working members, and the honour was none of his seeking. But since they had been pleased to call him to the office once more, he felt that it would be a slight to their confidence if he merely consulted his own personal inclinations in the matter. So, in taking the chair at the beginning of a new term and a new year, he trusted they would excuse any shortcomings on his part, and he would sincerely endeavour to return their kindness by an increased interest in their success.

There was one fact which the President thought was fair subject of congratulation for the Society, since it showed the interest taken in its proceedings throughout the School, and seemed, to him at least, an indication of material stability. Their numbers largely increasing of late, they had found it necessary to place some limits on the membership, and had fixed it at seventy (sixty members from the Upper, and ten from the Junior School). He was glad to say that this plan had worked remarkably well; indeed, so numerous were the candidates for admission, that it was thought unfair to allow useless members to remain there (and a few such stray wolves had, of course, found their way into that little fold). So, by a rigid system of compulsory attendance at meetings, those who liked to have the privileges without the duties no longer were attracted to the Society, and room was thus made for more zealous adherents.

The President then went on to contrast the present state of things with the past, showing how that, little more than a year before, they had only had seventeen members, but that they had now been able to maintain the definite number of seventy for two terms, although the winter had afforded none of the 'bait' in the way of excursions or *soirees* which the invidious had erroneously supposed to form an inducement to membership. He had good reason, he thought, to believe that this prosperity would not be ephemeral. Comparing the statistics of attendance at meetings with those of other School Societies, he found

that the average number present on each occasion for the past year was at Clifton much the largest. Of members, too, they had seventy, while Marlborough had twenty-four, Rugby twenty-two, Harrow thirty, and Cheltenham thirty-three. He knew that 'comparisons were odious,' and he did not in any way intend to laud his own Society, and decry others with which they were on most friendly terms; but he merely wished to show that they were coming to the front in this respect, and he only hoped that they would try to emulate some of these Societies in other points too, wherein there was still much to be done.

The speaker next alluded to the forthcoming 'Transactions,'* and showed how busily the Sub-Committee had been employed with preparing the book. He then went on to describe the present condition of the Museum and Botanic Garden. In the Museum they had caused handsome cases to be erected, and a large fund had been subscribed to pay for them. The Herbarium was being revised, the shells had been all arranged, Mr Greene was working at the Lepidopterous collection, and a considerable series of British birds had been already obtained. They did not mean to turn their Museum into a lumber-room or a mere dusty receptacle for the useless trash termed 'curiosities,' which non-scientific people so often gathered around them. Every one who had been connected with a Museum knew how ready people were to give that which cost them nothing, and how frequently the 'donation of specimens' meant merely the convenient disposal of what had become as devoid of ornament as it was of use. They intended to be somewhat eclectic with regard to offers from intending contributors, for much as they valued the kindness of those who might make those offers, they valued the real usefulness of their Museum still more. The space was small, and it was of great importance, he thought, that the collection should be educational and complete. Hence the settled limits laid down were,—First, a museum of *British* Natural History and Antiquities, with an especial local series; and secondly, a typical set of zoological and botanical specimens for the use of scientific students and the illustration of lectures. He earnestly solicited assistance in carrying out this plan, and he was gratified in being able to say that almost every day brought some new accession to their collections. He would gladly furnish lists of desiderata to those who applied to him for them. He hoped, also, that there would be some boys found to volunteer their help in arranging, labelling, and cataloguing. His own engagements did not admit of him undertaking it all himself.

* Transactions of the Clifton College Scientific Society, Part I., published in March 1871.

The President further reported a long list of contributions to the Botanic Garden, received from many friends. He instanced especially the generous help extended by the Directors of the great gardens at Dublin, Edinburgh, and Glasnevin, and spoke of further gifts expected from similar institutions. He felt sure that there would be no difficulty in enlisting many botanical friends in the formation of this Garden, which was destined to be of great practical use to the School. From another point of view, he believed it would be valued by the non-botanical as a welcome substitute for a most unsightly and useless piece of ground. It was not to be the mere collection of painted sticks and coarse weeds that formed a typical botanical garden in the mind's eye of those who had never seen such a garden; but he meant to have it a really pretty ground, and he would not absolutely sacrifice the ornamental to the useful.

Noticing next the formation of 'sections' which he had proposed, the President gave some details about the subjects which were to be taken up in each. He urged the importance of practical observations among those who intended to study meteorology, and he showed how these might be taken. The Society already possessed a fine barometer (the gift of F. F. Tuckett, Esq., Hon. Mem.), and other instruments would be forthcoming if workers only offered themselves. There were, he said, considerable advantages for scientific pursuits in this College, and in some respects advantages not possessed by any other School of which he was aware. With five Science Masters, with facilities for instruction in almost any branch from the whole range of the Physical Sciences, and with practical instruction in Chemistry, Physics, and Physiology, it would indeed be surprising if Clifton College did not send forth some alumni who would yet take a high position in the scientific world. Again, they dwelt in a neighbourhood exceedingly rich in its geological and botanical characters, and they had this Scientific Society to bring together those of kindred tastes, and infuse an *esprit de corps* among fellow-workers. He earnestly hoped that many there might be led to new and delightful paths of intellectual pleasure, and that even more might be made to feel, when school-days had become a thing of the past, that their precious time had been turned to the best account.

A paper on the 'Steam-Engine' was next read by J. Duncuft and J. Stone.

The paper was opened by J. Stone with an account of the uses of steam, particularly as applied to the steam-engine; the

engine invented by Branca in 1629, Blasco de Garay's engine, Denis Papin's, and others, followed by a description of Thomas Newcomen's, which he illustrated with a diagram. The inventions of James Watt were explained at some length, and this part of the paper finished with Stephenson's locomotive. The following is an extract:—

'The steam-engine is the universal civiliser of the world. It has done more to increase human comforts, and render accessible to the poor man things unattainable without its influence, than any other invention. By means of it friends meet friends, sociable habits are cultivated and increased, nations are knit together in iron bonds of alliance, commerce has been extended, a new era has dawned for literature—in short, there is no art, science, or branch of industry that has not benefited directly or indirectly since the discovery of this subtle giant. We ought then to honour and hold sacred the names of those two Englishmen, Stephenson and Watt, perhaps the greatest benefactors of the human race, who, in bringing forward their inventions, had to struggle against obstacles of every sort, but with true English spirit overcame them all, and lived to see the beginning of their good work.'

J. Duncuft next described at length Watts' 'Double-action Engine, and Parallel Motion,' giving also an account of the locomotive.

The lecture was illustrated throughout with diagrams and working-models. It was received with much applause.

MEETING, Feb. 17, 1871.

The President in the Chair.

The second meeting for the term was held on 17th February. There were fifty-five members present.

J. G. Grenfell, Esq., was elected an Honorary Member.

The President brought before the meeting full details of the proposed plan of working by 'sections.' He stated that it had been determined to found seven sections in all, and that each section should have ten members. A Director would have to be appointed over each, and the President and Secretary were to be *ex officio* members of all.

A motion, based on this plan, was passed unanimously.

The President then read the names of the sections, and, after some discussion, the following Directors were elected by vote:—

Botany, . .	M. J. Barrington-Ward, Esq.
Geology, . .	J. G. Grenfell, Esq.
Entomology, .	Rev. J. Greene.
Archæology, .	R. W. Wilson.
Zoology, . .	J. F. M. H. Stone.
Chemistry, .	G. F. Rodwell, Esq.
Physics, . .	J. Perry, Esq.

Thirteen new rules for the management of the Society (which had been drawn up by a Sub-Committee) were then brought forward and passed. They have been inserted, with the others, at the beginning of the present Number.

MEETING, Feb. 24, 1871.

The President in the Chair.

The third meeting for the term was held on 24th February, in Big School. There were over four hundred members and visitors present.

Mr Lovell Squire, of Falmouth Observatory, gave the following lecture on—

THE METHODS OF OBSERVATION IN THE METEOROLOGICAL OBSERVATORIES OF GREAT BRITAIN AND IRELAND.

In his introductory remarks, the lecturer alluded to the importance, in a country like this, so largely engaged in commerce, of laying down some general laws by which we might be able to forecast the weather, and warn masters of vessels of impending storms. To attain this end was the main object in establishing the Meteorological Observatories, supported by means of an annual parliamentary grant. Admiral Fitzroy had previously carried on a noble and useful work; and we cannot withhold our admiration of his energy and devotedness to it. Still his failures were numerous, and he attempted more than the state of meteorological science justified him in undertaking. After his death, in 1866, the storm-signals were discontinued for about a year; but a desire gradually increased amongst

those connected with shipping that they should be resumed. The Board of Trade, to whom the annual grant was made, referred the subject to the Royal Society, and it was ultimately arranged that a committee of that body should take the entire control of the grant, and make an annual report to Parliament. Of that committee, Lieutenant-General Sir Edward Sabine, K.C.B., the venerable President of the Royal Society, has been the Chairman since its formation. The storm-signals were resumed in a modified form, and it was resolved to establish meteorological observatories in different parts of Great Britain and Ireland for registering observations, and collecting reliable statistics of the weather. The committee hope that these may ultimately serve as data for more definite laws regarding atmospheric disturbances, and the approach and force of storms.

During the years 1867 and 1868, six observatories were started and in working order, subordinate to the central observatory at Kew, which was under the able direction of Dr Balfour Stewart, F.R.S. The results of all the observations, after having been examined at Kew, were sent to the office of the Meteorological Committee of the Royal Society in London. These six observatories were placed as follows:—In England, at Stonyhurst and Falmouth; in Scotland, at Aberdeen and Glasgow; in Ireland, at Armagh and Valentia. All the instruments supplied to them were first carefully tested at Kew, and made referable to one common standard, by which means the registers admitted of exact comparison.

The principal instruments are *self-recording* and *continuous* in their registers, viz., the anemometer and anemograph, for registering the velocity and direction of the wind; the barograph, for registering the pressure of the atmosphere; and the thermograph, for registering the temperature of both the dry and wet bulb thermometers.* There are other instruments subsidiary to these—a standard barometer, two standard thermometers, maximum and minimum thermometers, and a chronometer.

At Falmouth, the instruments are placed in a tower about fifty feet high, built expressly for the purpose. Its summit is about two hundred and twenty feet above the sea, and it consists of four storeys, with a flat roof, on which is placed a stage for the anemometer; this communicates with the anemograph in the upper storey. The barograph is in the basement, which is sunk a few feet below the level of the adjoining ground; the

* Since this lecture was delivered, a self-recording rain-gauge has been supplied to each of the observatories.

thermograph in the next storey above; the intermediate storey being used as an office.

The construction of the various instruments was explained by means of numerous and well-executed drawings, without which it would be impossible to give more than a brief and general description.*

The velocity of the wind is registered by means of four copper cups placed at the extremities of two horizontal cross bars, four feet long, which turn a vertical rod. This rod is connected by wheel-work, and another rod, with a metallic pencil, which draws lines (more or less rapidly, according to the force of the wind) on a sheet of paper kept travelling, at a uniform rate, in contact with it, by means of clock machinery. In consequence of the wind meeting with a greater resistance from the concave than from the convex surface of the cups, these always turn in the same direction. Still the motion is much retarded by the resistance of the convex surface, and it is calculated that the rate at which the cups move is one-third of the rate of the wind. A line on the register-paper, representing fifty miles passed over by the wind, is drawn when the cups have revolved 7000 times. Immediately such a line has been drawn, the pencil begins to mark another line. Sometimes in the course of twenty-four hours, only one or two such lines are drawn; sometimes as many as twenty or more. The highest register *in one day*, was on February 3, 1869, when more than twenty-three such lines were drawn, representing 1172 miles. The greatest velocity registered *in one hour* was 73 miles, on September 12, 1869. At this rate the cups would revolve nearly three times in a second.

The direction of the wind is shown by means of a heavy vane, which is kept turned towards the point from which the wind blows, by two fans similar to those which are used to keep the sails of a mill towards the wind. The direction is registered on the same paper as the velocity, and in nearly the same manner.

The variations in the barometer and thermometer are registered by the aid of photography, which, while it successfully and beautifully accomplishes the object required, does not, in the least degree, interfere with the free action of the quicksilver. Sheets of waxed paper, each 19 inches long and 6 inches broad, are prepared with iodide of silver, so as to be very sensitive to the action of light. Two of these sheets are placed round a vertical cylinder, which is inclosed in a sort of wooden case to

* Most of these were drawn on a very large scale from the figures in the Report of the Meteorological Committee for 1868, in which a minute description will be found.

exclude daylight, and is kept by means of a clock slowly revolving on one side of a barometer, whilst a gas-light is constantly burning on the other side. The light cannot pass through the mercury; so the only effect produced upon the sensitized paper is from the light that passes through the space between the surface of the mercury and the top of the tube. This space is, of course, larger or smaller, according as the mercury falls or rises; and the black band on the paper will be proportionally broader or narrower. Thus the variations of the lower edge of this band become a faithful representation of the changes of height in the mercurial column. There is a mechanical contrivance connected with the clock, by which the light of the gas is intercepted during four minutes, at every even hour, thus leaving a white line on the photograph, which accurately points out the hour.

By means of a tabulating instrument, the barogram is measured at every hour to the thousandth of an inch, and the record entered on sheets ruled for the purpose.

The changes of temperature in the dry and wet bulb thermometers are also photographed, though in a rather different manner. A vertical cylinder, covered with sensitized paper, as mentioned above, is made to revolve by a clock, as has been already described with reference to the barograph. The thermometers are placed within a screen outside the building, about three feet from the wall, and being bent at a right angle, they come through the window-sill into the thermograph room. Towards the top of the thermometer there is a small detached column of mercury, separated from the rest by a little speck of air, and as the temperature varies, the air-speck rises or falls also. The gas burners in the room are reflected by highly polished mirrors upon the upper portions of the thermometers, and the light, passing only through this small interstice formed by the air-speck, falls upon the sensitized paper, and marks a line, more or less wavy, according to the changes of temperature. The hours are marked on the curve by cutting off the light in the manner already described; and the results are tabulated and recorded for every hour.

The thermometers commonly in use for ascertaining the maximum and minimum temperatures, may give pretty accurate results, but they do not, of course, record *when* these extremes occurred. By means, however, of these continuous curves, we are enabled also to fix the exact time of their occurrence. One singular fact is thus made known to us—that the maximum temperature is occasionally at or near midnight. Thus during

January of the current year, the maximum temperature was as follows on the days specified :—

January	1	... Midnight.
,,	4	... 0.40 a.m.
,,	7	... 1.10 a.m.
,,	15	... 11.55 p.m.
,,	16	... 1.30 a.m.
,,	25	... 0.5 a.m.
,,	31	... 0.5 a.m.

As was remarked respecting the barometer, this work is also tabulated for every hour, and entered on paper ruled for the purpose.

Nearly all the work is tabulated twice, in order to detect inaccuracies. The whole is carefully examined at Kew, and portions are again tabulated there so as to test their accuracy, and remove, if possible, all doubts of their correctness.

Thus, these observatories supply *hourly* records of the rate and direction of the wind, the pressure of the atmosphere, the temperature of the dry and wet bulb thermometers, and (as soon as the gauge is in working order) the quantity of rain—together with many subsidiary records and observations of the clouds and state of the weather, made several times in the course of the day. Such a mass of valuable and reliable data can hardly fail, in the course of a few years, to fix meteorological science on a firmer basis, and to establish more definite laws for forecasting the weather. It is to be hoped that the Royal Society, which is devoting so much time and attention to this subject, will see abundant fruits of their labours. The Meteorological Committee have issued Quarterly Weather Reports for 1869, in which the curves of pressure, temperature, and wind, as sent in from the seven observatories, are lithographed and accompanied with many illustrative and valuable remarks by the Director, Robert H. Scott, Esq., F.R.S. The same is in course of preparation for 1870.

The lecturer made some remarks, in conclusion, upon the value of meteorological pursuits to young persons, not simply on account of the science itself, but because the observations, if they are to be worth anything, must be made with great care and truthfulness, with strict punctuality and untiring perseverance. Thus the cultivation of sound moral habits would go hand-in-hand with the pursuit of useful knowledge and physical science.

The President made a few remarks at the close, and a vote of

thanks to the lecturer (proposed by the Rev. T. E. Brown, and seconded by E. Ward Jackson, Esq.) concluded the proceedings of the evening.

MEETING, March 10, 1871.

The President in the Chair.

The fourth meeting for the term was held on 10th March. There were sixty members and visitors present.

The President announced that the Committee had elected John Perry, Esq., B.E., and the Rev. H. N. Ellacombe, M.A., of Bitton, Honorary Members. He then, in a short speech, mentioned the loss the Society had sustained by the death of Dr Symonds, an Honorary Member.

D. Pearce read the following paper on 'The Mole,' illustrating the subject with specimens and diagrams :—

The mole is, I think, the most interesting of all our burrowing mammalia. It belongs to the genus *Talpa*, which consists of two species only, viz., *Talpa Europea* and *Talpa Asiatica*. Its interesting character lies not in its merely burrowing a passage, like the rabbit and many other burrowing mammals, but in its making a most complicated and intricate subterranean dwelling. This consists of a high-road and numerous branching passages, undermining an enormous space of ground, when one considers the size of the animal in question. I will first proceed to give a general notion of the common mole. It is from five to six inches long, including the tail, the body being very thick and almost cylindrical, and the head prolonged into a pointed muzzle, which projects considerably beyond the jaws of the animal. This muzzle is, of course, very strong and muscular, else it would not be suited for its laborious life. The mole's ears are not external, but still its hearing is most acute; a fact which can be easily shown by walking over the ground or causing any sudden vibration to the earth. If this be done, the mole will very soon be seen to change the direction of its burrow, or suddenly cease throwing up earth, if employed in making a hill. The eyes of the mole are very minute and almost imperceptible; this fact also shows how admirably the structure of the little animal is adapted to its mode of life. The front feet project very little from the body, but they are nevertheless very stout and strong, while the hind feet are much weaker. I will now proceed to speak of its subterranean

dwelling. The mole makes a choice, if possible, for the situation of its runs, a place generally being selected of an earthy soil, and consequently easiest to burrow in. It first proceeds to make a central high-road; then branching out from that, it forms on both sides numerous passages which lead to the hunting-grounds, as they are called. Then the dwelling itself is constructed, which generally lies under a hedge or wall that may afford it some protection. The construction of this abode is most wonderful, and I will take the following account of it from 'Wood's Natural History,' as I have not had an opportunity to examine one myself:—'It consists of a central compartment, the roof of which is nearly level with the earth, and therefore situated at a considerable depth from the apex of the keep. Around this keep are driven two circular passages or galleries, one just level with the ceiling, and the other at some height above. The upper circle is much smaller than the lower. Five short descending passages connect the galleries with each other, but the only entrance into the keep is from the upper gallery, out of which three passages lead into the ceiling of the keep. It will be seen, therefore, that when a mole enters the house from one of his tunnels he has first to get into the lower gallery, to ascend thence to the upper gallery, and so descend into the keep.'

The walls of the keep and different runs become excessively firm and solid, and are proof against the severest storms. This is caused by the constant friction of the mole's fur against the sides. But the wonderful fortress just described is not the only one made by the mole. It also forms a separate compartment, or nursery, for rearing its young. This is generally made at the junction of two runs, and consists of a single chamber, with a nest formed of dry grass and blades of corn.

I will now give a short description of the hunting-grounds wherein the mole spends much of its time, only making use of the fortress in the autumn and winter months.

A high-road is first made, which leads direct into the fortress, and this road is larger than those subsequently made, but at the same time not large enough to allow of two moles passing abreast. From this road on both sides passages open, and it is in the construction of these that the mole throws up the well-known 'mole hills.' These mounds in themselves present nothing worthy of notice, and are merely heaps of débris round the shafts through which the mole gets rid of its excavated material. The depth to which the runs are made in the earth varies a great deal according to the weather and the consistency of the soil. In wet weather they are placed very near the surface, and sometimes they are merely trenches, the reason for this being, that in damp weather

worms and insects are mostly found there. It is interesting, on the other hand, to observe, that when the run of a mole leads under a road or any other hard surface, you invariably find that it is as much as three or four feet deep.

Sometimes a mole will make a second run to facilitate the carrying on of its operations, and I believe that sometimes several moles use one road in common, though this is not often the case. The direction of the passages leading from the centre is generally slightly inclined downwards. As I have now given you a brief account of the fortress and hunting-grounds of this wonderful little creature, which can almost rival the more celebrated beaver in architecture, I will proceed to describe the animal itself.

At first sight one might very naturally wonder how so dull and clumsy-looking an animal could lead such a strange and laborious life, and perhaps a feeling of pity would almost arise for its seeming helplessness. But I assure you this is not at all needful, for the mole is one of the most ferocious of all animals, considering its size. It can fight with inconceivable ferocity, and is excessively agile when in its element, while it seems to be endowed with a never-ceasing activity. The following I take from the Rev. J. G. Wood's work, already referred to :—'A battle between two moles is as tremendous as one between two lions, if not more so, because the mole is more courageous than the lion, and, relatively speaking, is far more powerful, and armed with weapons more destructive. Magnify the mole to the size of the lion, and you will have a beast more terrible than the world has yet seen. Though nearly blind, and therefore incapable of following prey by sight, it would be active beyond conception, springing this way and that as it goes along, so as to cover a large amount of space, leaping with lightning quickness upon any animal which it meets, rending it to pieces in a moment, thrusting its bloodthirsty snout into the body of its victim, eating the still warm and bleeding flesh, and instantly searching for fresh prey.' But remove the mole out of its proper sphere, and it becomes at once a most inactive, stupid-looking animal.

The mole generally works for food about two hours in the morning and as many in the evening, and I believe it always rests in the middle of the day.

If a mole, soon after it has been captured, be placed on the earth, burrowing is immediately commenced with inconceivable rapidity, so that in fact the earth seems almost to yield to its pressure. An observation on the rapidity of the mole's progress underground was made by a Frenchman, Le Court, to whom we are indebted for a monograph on this very interesting animal. He placed some little twigs at intervals in the run of a mole, and

then introduced a horn at one end (having first ascertained that the mole was in the run). He then began blowing it loudly. The mole immediately rushed along, knocking down the twigs; and he considered that it went as fast as a horse could trot at its greatest speed.

During pairing-time the mole is exceedingly fierce, and two males cannot meet without a mortal conflict ensuing. Sometimes they even venture out of their runs to fight, and when this is the case, they can be easily approached and captured, so intent are they on battle. The pairing season takes place late in the spring. The mole generally has four or five at a birth, but never less than two. The young moles begin to run in about five weeks, but they do not then leave their mother. Jesse, in his 'Natural History,' says that a mole-catcher once found, on taking a female out of the trap, five young ones clinging to her, none of which made any attempt to escape.

The appetite of the mole is wonderfully voracious. Its food chiefly consists of worms, but even birds and frogs, or snails, are sometimes eaten as well. It will not, however, touch a toad. The attitude of the mole when devouring its prey is very curious: it draws its back up, retracts its head between the shoulders, and pushes the worm into its mouth with its fore-paws. A very short fast is fatal to it; in fact, when two moles are kept in confinement together, and not sufficiently supplied with food, the weaker is invariably killed and devoured by the stronger, even to the very bones, the skin alone being left. I have read that ten or twelve hours is the longest period they can live without food, but this seems to contradict Linnæus's statement that the mole is torpid in winter.

Another fact which seems to prove that the mole does not become torpid is, that just before the winter season commences it makes a basin of clay and fills it with mutilated worms to provide for its wants through the winter months. It is also a well-known fact that it sinks wells in the dry season, but this is only done when a pond is not sufficiently near, for if one be at hand a run is invariably found leading to it. The mole can swim very well indeed, and in the case of floods, or when about to change its abode, it often takes to the water.

The skeleton of the mole is worthy of a brief notice. On examining the animal you at once see that its entire strength is centred in its forequarters, the shoulder-blades being of enormous size, and projecting far above the spine, while the muscles of the neck are also very powerful, and the ligaments are hardened into bone. The nose, too, is furnished with an accessory bone, that projects into the snout, and gives it great strength and mobility. The

wide hand, which is the great instrument of action, is sharpened on its lower edge, and the outstretched claws are strong and flat. The fur of the mole (as indeed of all our burrowing mammalia) is always perfectly free from dirt; this is, in part, owing to the peculiar construction of the hair; for it will be noticed that the hairs do not point in any particular direction, that is, the fur has no 'set.' A strong muscular layer lies beneath the skin, and by means of this the animal is enabled to give itself a powerful shake, which at once frees it from all the mould collected on the fur. It is remarked by the Rev. J. G. Wood, in his account of the mole, that there is an accessory bone, shaped something like a sickle, projecting from the carpus; and he says that in this extraordinary animal still exist certain remarkable peculiarities of structure which are seen in no other living form, but have been discovered in the fossil skeletons of animals long extinct. I trust that the account I have given, however imperfect it may be, will show you how many interesting points there are in the habits and structure of an animal found so commonly in our fields, that by a great many it is despised, and not thought worthy of consideration.

J. C. Prinsep then gave a lecture on 'English Architecture,' and exhibited a large number of well-executed sketches and plans. The President and the Rev. J. Greene afterwards commented on the paper, referring especially to the subject of the revival of Gothic architecture in England. The Rev. J. Greene brought forward the following resolutions, which were passed unanimously:—

I. That members be requested to bring for exhibition at the meetings of the Society specimens of Natural History, and illustrations of Natural and Physical Science in general.

II. That members be invited to present donations of specimens to the College Museum when they may have it in their power, such donations to be acknowledged in the Society's Transactions.

The Society then proceeded to the election of Directors for the Chemical and Physical Sections, in the room of G. F. Rodwell, Esq., and J. Perry, Esq., who had declined the office.

For the Chemical Section, G. T. Atkinson, Esq., Messrs P. R. Ogle, and W. A. Smith were proposed. On a ballot being taken, W. A. Smith was elected. W. J. P. Wood was afterwards elected Head of the Physical Section.

MEETING, March 31, 1871.

The President in the Chair.

The fifth meeting for the term was held on 31st March. There were seventy-nine members and visitors present.

F. L. Penney read a paper on the 'Carboniferous Limestone of Clifton,' and exhibited a large number of specimens of rocks and fossils, mainly collected by himself.

G. F. Rodwell, Esq., next read a paper on 'Energy, Potential and Actual.'

M. J. Ward then gave an interesting account of 'Curious Birds' Nests.' Most of the forms of nest mentioned in the paper were illustrated by well-executed coloured sketches. It was the first contribution to the Society from a member of the Junior School.

MEETING, April 4, 1871.

The President in the Chair.

The sixth and last meeting for the term was held on 4th April. Thirty-nine members were present.

The business of the meeting was the election of office-bearers for next term.

For the office of Treasurer, the Rev. J. Greene was proposed, but Mr Greene expressed his regret that he could no longer occupy that post. He had no objection, however, to become an ordinary member of the Committee, should the Society honour him by electing him.

Messrs R. F. Brunskill, W. A. Smith, and R. W. Wilson were then nominated for the Treasurership, and the first-named gentleman was elected.

A large number of candidates (fourteen) were brought forward for the vacant seats on the Committee, and from them the following were declared elected:—Rev. J. Greene, J. F. M. H. Stone, R. W. Wilson, and T. H. Warren.*

* At a subsequent meeting of Committee, J. Stone was appointed to act as Secretary.

After some discussion on the work of the Sections, the Rev. J. Greene proposed the following resolution, which was passed :—

'That the Directors of the different Sections be invited to communicate to the Society any matters of interest which may have come before them ; and that such communications be made at the commencement of each public meeting, at least one day's notice having been given to the Secretary.'

The Rev. J. Greene announced donations of Lepidoptera for the Museum from the following ladies and gentlemen :—Mrs Hutchinson, Grantsfield, Leominster ; Mrs Battersby, Westmeath, Ireland ; Rev. E. M. Blomfield, Hastings ; G. Lock, Esq., Newport, Monmouthshire.

The President announced the following contributions to the Museum and Botanic Garden :—(*Museum*), Ammonites, by Joshua Saunders, Esq., Hon. Mem. ; Fossil Fish from the Devonian Series of Stromness, by the Natural History Society of Marlborough College ; 'Stick' and 'Leaf' Insects, by F. L. Maisey. (*Botanic Garden*), Flowering Plants, 116 by the Royal Botanic Society, Regent's Park, London ; 150 by the Rev. H. N. Ellacombe, Bitton ; 215 by the Board of Trinity College, Dublin, through Professor Percival Wright ; 180 from the Royal Botanic Garden, Edinburgh ; 150 from the Royal Botanic Garden, Glasnevin ; 60 Shrubs and Plants from Joshua Saunders, Esq., Hon. Mem. ; and 150 Shrubs and Trees for the Arboretum from Thomas Proctor, Esq., Hon. Mem.

SECOND TERM, 1871.

MEETING, May 12.

The President in the Chair.

The first meeting for the term was held on 12th May. There were fifty-eight members and visitors present.

The Rev. J. Greene acknowledged the receipt of donations of Lepidoptera from E. Birchall, Esq., and G. Baker, Esq., Derby. The President said that he had received the Transactions of the

Rugby School Natural History Society, and announced the following elections :—

Rev. E. HARRIS, M.A., *Honorary Member.*
H. E. CLERK, *Junior School Member.*
J. SWINBURNE, „ „ „

A joint paper was read by the President and Secretary (Messrs Barrington-Ward and Stone) on

A SCIENTIFIC VISIT TO CHEDDAR.*

On seeing Cheddar some months ago, for the first time, we found so much that was interesting in its cliffs, its caverns, and its antiquities, that we thought it would be worth while to give a more careful examination to them, and to communicate to this Society the result of our personal investigations. With this view we have again visited the district, and have seen almost all the points of interest once more, while, at the same time, we have availed ourselves of every piece of collateral information that we could procure, whether from the writings of others or replies to the inquiries which we made of various persons acquainted with Cheddar. And we must here acknowledge gratefully the courtesy of the vicar, the Rev. Richard Beadon, through whose valuable assistance we are enabled to lay before the Society many matters of interest connected with the early history of the church and village. In the following paper we propose, first, to say something of Cheddar village itself, and the general features of the country round it ; then to describe the cliffs, with the remarkable cavern, which forms the leading attraction of the place ; and we shall next mention some points of interest in its history and antiquities ; concluding with an account of the geological structure of the district, and such botanical notices as it may seem desirable to make.

Cheddar is a small village lying beneath the south slope of the Mendips, about eight miles from Wells and eighteen from Bristol. It is not a pretty village as a whole, and by no means a well-built one, but there are many charming glimpses of hill and woodland here and there between the scattered cottages, and the stately tower of the church rises majestically from the dense masses of foliage which surround it beneath. On the occasion of our second visit the exquisitely lovely tints of the opening leaves and the brilliance of the spring flowers lent a charm even to the humblest abodes. In few parts even of rich Somerset does vegetation thrive

* The Geological and Botanical parts of this paper have been mainly written by the President, and the Antiquarian by J. Stone.

as it does here. The laburnums were one mass of golden blossoms, the lilacs and honeysuckle filled the air with fragrance, and the gardens were gay with the brightest and largest of tulips.

Through the village runs a rapid brook, sufficiently powerful to turn several mills, and it is indeed curious to see how its waters burst forth abruptly at the base of one of the cliffs, as if from some great subterranean lake. The stream has been dammed up near its source by the millowners, and the lakes thus formed, though neither deep nor clear, yet by their reflections and the contrast which they afford to the stern grey rocks, add considerably to the beauty of the place. This river is named the Cheddar Water, and it is a tributary of the Axe. At one of the paper-mills which we visited (that of Mr Lang), we were initiated into the mysteries of the manufacture of 'hand-made' paper, and the sheets now exhibited, however coarse and uneven they may be, are at least our own productions.

To the south and south-west of Cheddar extends a broad open plain, called in part the 'Axe Level.' This flat ground is monotonous in the extreme, and it is but thinly populated. A large portion of it was a mere sheep-walk till the year 1801, when an enclosure was made which has been most beneficial to the district. Oats, barley, and even wheat are now grown on many parts of it; and farms have been formed as well, where especial attention is given to the manufacture of Cheddar's well-known produce—the famous 'Cheddar cheese.' Above the village, on the north, rises abruptly, often almost precipitately, the range of the Mendips. Beginning at Uphill (close to Weston-super-Mare), running in a gentle southerly curve to Wells, these hills finally take an eastern direction, and may be said to end at Frome. They extend about twenty-five miles in length, and usually form several parallel ridges four or five miles wide. The Mendips are not of lofty elevation, the highest point (Black Down) being but 1080 feet above the sea level. In physical features the range has not much that is remarkable, save in the extraordinary defiles that here and there intersect it, as at Cheddar and Wookey. Smaller breaks are in many parts of it abundant, and, being generally rugged and richly wooded, they form dells and passes of the most romantic beauty. Rickford and Burrington 'Combes' are valleys of great interest, though not so much resorted to as Cheddar, whilst the verdure-clad rocks of Brockley Combe will be fresh in the memory of many here this evening who saw it last year, unfortunately under circumstances the most adverse.*

The general aspect of the Mendip Hills is that of a bare series

* The allusion refers to the Society's picnic in July 1870. The day was exceedingly wet and disagreeable.

of rounded eminences, cultivated and planted only in their lower portions. Yet forests of well-grown timber most probably once covered these bare slopes, and, as we shall presently see, England's monarchs even followed the chase over them. It is much to be regretted that no attempt is made to restore to the hills that covering of which they have been so long deprived. The benefits derived from the plantation of similar bare slopes have been so great that it is strange the experiment has not been tried here. The lower portions of the Mendip Hills are often of the greatest possible fertility, and immense crops of early potatoes and peas find their way hence to the Bristol markets at a time when those valuable commodities are as yet unheard-of elsewhere.

We must now glance at the cliffs of Cheddar, which, as we have said, overhang a deep defile cut through the very midst of the Mendip range. This pass begins in the village, and it thence takes a north-easterly direction, extending through the hills for about two miles. One of the first objects seen on entering the glen is the remarkable Lion Rock. This is a grassy slope rising about 150 feet from the road on the right hand, and crowned by what is apparently the colossal effigy of a recumbent lion carved in the living rock. The likeness is really most extraordinary, and it is at first almost difficult to believe that the hand of man has had nothing to do with its formation.* But a closer inspection shows the eye, the nostril, and the mouth to be formed merely of grass, ivy, and other plants which have taken root on projecting ledges, while the illusion is wholly dispelled on passing farther up the defile and looking back, when the form of the mighty guardian of the pass is found to have disappeared altogether. There are unfortunately abundant cracks in the limestone rock which thus simulates so wonderfully the lion's huge shape, and ere long much of it will doubtless fall away.

The approach from the village is extremely pleasing, and that in no small degree from the fact that the transition from plain to valley is exceedingly abrupt. At one moment we are on the most level of ground; a few steps farther and a sudden turn brings us into a rocky gorge between cliffs and crags that tower up on either side of us. It is like witnessing a dissolving view of some place in Holland, which melts in turn into an Alpine pass. The scenery of the cliffs is of the grandest kind, and it is no exaggeration to say that there are few things in England to be compared with it. It rather reminds one of something in the Tyrol or the Scottish Highlands. Towards the right the rocks are considerably taller than on the opposite side, and the effect produced by the precipi-

* For the illustration of the Lion Rock, we are indebted to the kindness of Mr Bryne of Cheddar, the publisher of Mr Stevens' excellent 'Guide.'

tous character of their abrupt faces is so striking, that the altitude seems much greater than it really is. What appears to be a thou-

sand feet turns out, when measured, to be really somewhat under five hundred. Yet, in spite of this somewhat moderate height, the whole scene is, as we have said, exceedingly fine. The road at the bottom of the gorge winds through the cliffs almost in serpentine fashion, and, on the right side, bold and almost perpendicular precipices tower aloft like huge battlements. Here and there ledges of jutting rock afford scanty soil for small trees of

mountain-ash, yew, &c., and in other spots brilliant wild flowers and luxuriant ivy grow in the greatest profusion, apparently from the solid rock. Ferns, again, are most abundant, and frequently there comes a break in the steep face of the cliffs, whereon a highly-inclined but by no means inaccessible bank of grass or gravel gives an opportunity to the adventurous to climb to a great height. But climbing at Cheddar Cliffs is by no means safe, from the extremely friable nature of the stone, and the tree-covered ledges which we have noticed can hardly be reached except by the most expert. The opposite side of the gorge is much less steep, and, in fact, much less picturesque. We had the opportunity of seeing a fine sunset on the occasion of our second visit to the cliffs, and the effect produced by the golden and ruddy tints of the last sunbeams lingering on the summits, while the pass below was shrouded in darkness, would have formed a fit subject for the canvas. Word-painting indeed is ineffectual to portray the lovely bits of scenery to be found at Cheddar Cliffs, and the landscape artist would there find much to employ both brush and pencil. There are certainly not less than ten points of view, completely different in character, each vested with its own charms, and all of them of surpassing beauty. An artist, writing some years ago in *Blackwood's Magazine*, has thus described his impressions of a visit to this wonderful scene :—

'No one can form an idea of the peculiar beauty, I should say grandeur, of these cliffs, without studying them. From the general line of the country no suspicion could be entertained of so fine a pass existing among the Mendip Hills—there are indeed many passages through them of various character, but there is not one to be compared to that of Cheddar ; indeed, there is nothing like it anywhere, so far as my judgment goes. The rocks are in character the finest, in places perfectly precipitous to the depth of perhaps 400 feet—they are magnificent in form and colour, and the numerous caverns and holes add much to the sublime nature of the scene ; it is certainly much finer than the Pass of Llambarris. It is a circuitous and narrow course, and so retired and sheltered within its own recesses that you think not of its utter barrenness—you are involved, as it were, in a deep wood of rock. Many years since I visited it and sketched there. An artist cannot find better studies for rock in detail, and should he be disposed to make pictures of such subjects, he will find many as perfect in composition as he would desire. There is a kiln at the entrance, the smoke of which rolling among the rocks produces a fine effect ; here, too, he will find admirable studies of caverns of every shape and depth. What a scene for a land storm ! I think few would wind through this sublime Pass with-

out a sense of fear; the rocks hanging overhead, threatening to crush the intruder, and the yawning chasm close upon his footsteps, seem prepared, as if by magic, for his prison in the grave. It is the region for genius and enchantment.'

The Caves.—Limestone rocks generally have an abundance of caverns and fissures, and many of them have been long known in the Cheddar Cliffs. But there are only two of any extent, of which one is especially remarkable for its beautiful stalactite formation. The larger cave was opened many years ago; it penetrates the cliffs more than 300 feet, in a south-easterly direction; but it has not many points of interest. A few stalactites which it contained have been ruthlessly broken off, the walls have been disfigured by the initials and marks of various obscure plebeians, who with characteristic bad taste always take care to leave records of their unworthy visits on every spot of interest, however hallowed by association or time, or however adorned by nature and art. The other cavern, called *par excellence* the 'Stalactite Cavern,' is exceedingly worthy of inspection, for, like the cliffs beneath which it lies, it is unrivalled in England, if it has its equal elsewhere. This cave was accidentally discovered by a miller named Cox, in 1837, and it now forms a valuable property for his family, who exact a somewhat excessive charge from visitors to it. The entrance is in the lower part of the glen, opposite to an inn (whose accommodation—from experience—we cannot commend). On entering through a long mean porch, the cavern appears at first completely dark, but a somewhat theatrical, though very pretty and striking effect is soon produced, by the lighting of numerous *gas-burners*, scattered in every corner and nook of the winding passages. So soon as the eye becomes accustomed to the light, the scene appears in all its beauty. Elegant folds of stalactite, seemingly interminable, hang down like the most beautifully arranged drapery from a lofty roof, apparently of immense height. Pillars and pendants of sparkling brilliance surround one on every side. Vistas stretch out through long rows of columns scattered in endless profusion—the melodious trickling of water sounds sweetly on the ear, glittering drops like diamonds fall in steady succession into crystal pools below. It is a very fairyland! When the guide touches lightly with a rod some of the clustering folds overhead, harmonious notes, in musical succession, are given forth, the tone varying, of course, according to the thickness of the stone. The stalactites are in the most perfect preservation, thanks to the good care taken of them. The rate of their formation is exceedingly slow—indeed, the guides aver that no increase whatever has been noticed in them since the cave was first discovered. The late Dean Conybeare has

borne testimony to the beauty of this cavern, and he compares it with the grotto of Antiparos. Elihu Burritt was struck with admiration at its wonders when he visited it on his walk from London to Land's End, and he says it is superior in almost every way even to the Mammoth Cave of Kentucky.

Curiously enough, we found in a font-like basin lying in one of the inmost recesses of the Stalactite Cavern, a large number of small crustaceans—furnished with the most perfectly developed eyes, although living most of the time in utter darkness.* Of course they may have been introduced in some way, and we only mention the matter for what it is worth, but the fact is, at all events, a curious one.

We are fortunately able to exhibit this evening a very beautiful stalactite, which came, as we understand, from one of the smaller caverns at Cheddar, though we are not acquainted with the name of the pilferer. A specimen so large as this is, of course, of considerable value. Time does not admit of an account of the way in which these beautiful productions of nature are formed, so we must now pass on to speak, as we have promised, of the history and antiquities of Cheddar.

The Antiquities.—Before entering upon a description of the antiquities of Cheddar, it would be well to give some explanation of the name itself. As far as we can judge from traditions and other sources, the village has borne the various names of *Cedre*, *Cheddre*, and *Cheddour*. The present name, *Cheddar*, is said to be derived from the Saxon word *Ced*, meaning 'a lofty height,' and *Dur*, 'water.' If such be its derivation, it has, without doubt, taken its name from the stream of water flowing through the valley wherein lies the hamlet, surrounded by lofty cliffs, which 'tower majestic to the skies.'

That the top of the cliffs and the surrounding country, now bare and woodless, was, in A.D. 975, clothed with extensive woods in which wild deer abounded,† may be assumed from the following story, taken from an ancient manuscript in the possession of the Corporation of Axbridge :—

'Sometimes, for the sake of hunting, the king‡ spent the summer about the Forest of Mendip, wherein there were at that time numerous stags and several kinds of wild beasts, for, as is read in the life of St Dunstan, King Edward, who sought retire-

* The specimens brought home for identification were unfortunately destroyed by an accident. They were of the order *Amphipoda*.

† At the same time, it must be borne in mind that the term 'forest' had a much wider signification in olden times than at present. Any large uncultivated district devoted simply to the chase, received the name of Forest, whether it was overspread with timber or not.

‡ Edward the Confessor.

ment at Glastonbury, came to the said forest to hunt, Axbridge being then a royal borough. The king, three days previously, had dismissed St Dunstan from his court with great indignation and lack of honour, which done, he proceeded to the wood to hunt. This wood covers a mountain of great height, which, being separated at its summit, exhibits to the spectator an immense precipice and horrid gulph, called by the inhabitants, "Chedder Clyffs." When, therefore, the king was chasing the flying stag here and there, on its coming to the craggy gulph, the stag rushed into it, and being dashed to atoms, perished; similar ruin involved the pursuing dogs, and the horse on which the king rode, having broken its reins, became unmanageable. In an obstinate course it carries the king after the hounds, and the gulph lying before him, threatens the king with certain death—he trembles and is at his last shift. In the interval, his injustice recently offered to St Dunstan occurs to his mind—he wails it, and instantly vowed to God that he would, as speedily as possible, recompense such injustice by a manifold amendment, if God would only for the moment avert the death which deservedly threatened him. God immediately hearing the preparation of his heart, took pity on him, inasmuch as the horse instantly stopped, and to the glory of God, caused the king, thus snatched from the perils of death, most unfeignedly to give thanks to God. Having returned to his house, that is, to the borough of Axbridge, and being joined by his nobles, the king recorded to them the cause of the adventure which had happened, and commanded Dunstan to be recalled with honour and reverence, after which he esteemed him in all transactions as his most sincere friend.'

The forest is also famous for its having been the battlefield of many fights between the Romans, the Saxons, and the Danes. The remains of their earthworks and camps are still to be seen. The earliest known inhabitants of Cheddar were the Hædui, a Celtic tribe, and if the destroying hand of cultivation in these days had but spared them, abundant traces of their houses and abodes might even now gladden the eye of the antiquarian. There are, however, some British tumuli scattered over the country adjoining the Cheddar Cliffs. At Priddy Hill one was opened in 1825, when it was found to contain the ashes of burnt bones and a few beads, like those from Egyptian tombs.

Nearly at the top of the road leading up the cliffs, and on the left side, far up the rocks, is a small cave in which some human skulls were found. An old labourer informed us that he remembered seeing them carried past his house on the way to some museum, so that the discovery is within the recollection of the

present generation. There are many and diverse accounts as to how these skulls got there, the most probable explanation being that they were part of the remains of warriors slain in the neighbouring battles, whose friends had placed them in the cave to save the trouble of burying.

The parish church of St Andrew, Cheddar, was erected between the years 1350 and 1450. It is a fine, substantially-built edifice, still in good preservation, standing in the midst of a churchyard well stocked with ancient tombstones. On its east side is a large yew-tree, with widely-spreading branches. These trees were planted in churchyards for many centuries after the Conquest, their branches being used not only for decorating the church on festive and other occasions, but also for throwing on the bodies at funerals. The leaves being always green were thought to resemble the immortality of the soul, and new shoots appearing in spring, after the boughs had been pruned, were likened to the resurrection of the body.

The church is 129 feet in length and 54 in breadth. It has a square tower, 100 feet high, surrounded on the top by a parapet of open carved stone-work, showing a quaint old gargoyle in each corner. The belfry, containing five bells, has a fine ornamental ceiling, divided into compartments. The inside of the church is in keeping with the exterior, in that it is substantially built, though not devoid of ornament. The nave is well lighted above by six clerestory windows on each side, the ceiling being of oak, in deep square sections, which in some places show traces of gilding.

On the south side of the nave is a grand old stone pulpit, richly carved in the perpendicular style of architecture, and showing evident traces of rich though inappropriate colouring. There are four small side chapels, one of which is now used for the vestry-room.

The nave opens direct into the chancel, on the north side of which, under a sculptured arch, and standing out from the wall, is the tomb of Sir Thomas de Chedder, the supposed founder of the church. A brass effigy of the knight is sunk in a large flat tombstone, and it is in excellent preservation. Sir Thomas is represented in full armour, which is apparently that of the fourteenth century. On the floor at the side of the tomb lies the brass of a lady, said to be Isabella, the wife of the above Sir Thomas, a piece of brass having been found near it bearing the words '**Isabella domina.**' We took rubbings of the two brasses, with the permission of the rector, and so are enabled to submit them to your notice.

On the south side of the chancel, exactly opposite the tomb, is a double piscina within a gothic niche.*

In the middle of the village stands the ancient market cross, battered and worn, but still bearing bravely the ravages of time. The old roof that used to crown it was, in 1834, replaced by a new one at the cost of the Marquis of Bath. The eaves and pillars afford a luxuriant retreat for an abundance of the beautiful *Polypodium vulgare.*

Before closing these few remarks on this part of our subject, we can only in justice say, that in investigating the ancient remains of this celebrated village, we received every courtesy from the inhabitants, who gave us all the information that lay in their power. There yet remains much for the antiquarian to do by original research, and we hope to see in some future number of Transactions a fuller account of the antiquities of Cheddar.

* We have been glad to learn that this venerable edifice will shortly be restored. Let us hope that the alterations may be but in keeping with the original features of the building, and may not become, as is too often the case in the now popular work of 'restoring,' flagrant super-additions instead of reconstructions.

Geology and Mineralogy.—We have already said something of the general physical features of the Mendip Hills, on the southern slope of which Cheddar is situated, and it remains that we should state their geological characters. The central axis of the range is one of old red sandstone, flanked by thick beds of mountain limestone. These latter rocks are inclined to the horizon at very various angles, sometimes of 30° and again as much as 70°. In most places they completely overlie the older sandstone, but in others it crops up to the surface through denudation. The amount of this denudation, we may say, along the whole course of the Mendips has been enormous. Professor Ramsay has even asserted that the missing beds, removed from the summit of the Mendips, must have been *almost a mile* in thickness! The extent of the conglomerate deposit which skirts these hills for so great a portion of their course, and fills up so many of the hollows in their rolling undulations, bears evidence to such an hypothesis, and Professor Ramsay fully supports it by his observations on the relation of the carboniferous limestone to the other rocks of this district.

The general character of the carboniferous limestone of the Mendip Hills is said by Professor Ramsay to be much the same as at Bristol; the lower shales present similar characters, the lower limestones are replete with encrinites, often shown, when weathered, to constitute the greater part of numerous beds, and the upper beds are often oolitic, corals being far more abundant in the latter than in the lower beds. There is more chert observable in the lower part of the Mendip beds, and sometimes this substance is abundant in them.*

As has been mentioned above, there is a very extensive deposit of what has been termed 'dolomitic conglomerate' flanking the carboniferous limestone of the Mendips. It rests unconformably on the subjacent strata, and is doubtless of Triassic age. At Cheddar this formation is abundantly seen, and at Draycot, in the neighbourhood, it is largely quarried under the name of 'pudding-stone.' We have seen polished specimens of the rock from these quarries, and it certainly forms a very beautiful marble, variegated with colours, owing to the many pebbles which it contains. It is their presence which gives it its curious name.

The flat expanse of the Axe level, lying at the base of the Cheddar Cliffs, is unquestionably an ancient estuary. Indeed, at no very remote period a branch of the Severn perhaps extended as far as Glastonbury Hill, and this great tract was only gradually converted into dry land by the deposition of mud from the waters.

* Ramsay, 'Formation of Rocks in South Wales and South-Western England,' Mem. Geol. Survey, vol. i. p. 127.

Artificial earthworks, too, lent their help in the process of reclamation, and there is some ground to believe that as early as the Roman occupation such dykes were constructed. Even in the present day, were the barriers removed, a high spring-tide would once more cover a great extent of the moor with water. Peat forms now the surface covering of the plain, and it is in many places not less than fourteen or fifteen feet in thickness. The evidence of an ancient sea-bottom is found in the bed of blue clay which underlies the peat, and beneath it again either the lias, or a kind of red marl, is occasionally seen.

The portion of Somerset which we are now describing is rich in mineral resources, and of these the most important is unquestionably coal. The enormous extent of denudation that the older rocks underwent did not affect several scattered portions, which were protected in the basins formed by the crumbling of those rocks. So every here and there we meet with detached patches of coal, fortunately spared to us, and they are found scattered over an area of about 188 square miles. There is a good example at Ashton, near Clifton, and many smaller beds might be named. Though the southern portion of this coal-field, in particular, is much covered by more recent accumulations, it is still extensively worked. The Mendip range is the south-western boundary of this district, and near Cheddar, so far as we have been able to learn, there exist no coal-mines. But this want is compensated for by the rich lead veins, which here extend through the mountain limestone of the Mendips into the dolomitic conglomerate.* At a very early date in history the mines of Wookey are known to have been worked, and those at Cheddar have a considerable antiquity. In Henry the Eighth's reign a lead tablet was dug up near the former village, and, from a Latin inscription observed on it, it is believed to have been affixed to one of the trophies 'erected by the Emperor Claudius to commemorate the final defeat of the Cangi by the Propraetor Ostorius, A.D. 49.'† In the Middle Ages the Mendips were famed for their lead-mines, and no small portion of the revenue of the Bishops of Bath and Wells accrued to them from these sources. Several remains of ancient smelting-houses may be seen within a few miles of Cheddar, and, though not worked with the same vigour as they once were, mining operations are still carried on at some of the old workings. One unpleasant result of lead extraction is the discolouring and contamination of the streams in the neighbourhood, and the consequent destruction of all fish in their waters. Calamine stone (the native carbonate of the protoxide of zinc, $ZnCO_3$) is also frequently met with in the Mendips, and it might doubtless be

* Lyell, 'Elements of Geology,' p. 769 (6th ed.) † Stevens's 'Cheddar,' p. 45.

worked much more extensively than at present. In Shipham and Rowberrow parishes, adjoining Cheddar, both calamine and zinc were once raised in some quantity. Ironstone and manganese have been found in small quantities on the hill surface, but no accurate search seems ever to have been made for them.

Botany.—The flora of Cheddar is a very interesting one, and indeed, there is a plant found here which occurs nowhere else in England—the beautiful *Dianthus caesius*, or 'Cheddar Pink.' This exceedingly rare species (which has very glaucous foliage, and large fragrant flowers of a rose colour) occurs plentifully on the cliffs, but unless some restriction be placed on its indiscriminate gathering, it must ere long be added to the list of species exterminated by the hand of man. For every one who visits Cheddar is solicited to buy specimens of Cheddar Pink, and several old women seem to derive their livelihood from this practice so nefarious (in a botanical point of view). The Pink can be readily grown, proper attention being given to soil and station —circumstances so commonly overlooked by those who try to naturalise it in their gardens. At Bitton, Mr Ellacombe has a fine specimen, growing on a wall in his interesting gardens, and we have ourselves been able to establish the plant in two places on the rockery of our new Botanic Garden. The Welsh Poppy (*Papaver Cambricum*) is another denizen of the cliffs: *Thalictrum minus*, too, is abundant. Among other plants found on the hills we might name the following: *Erodium moschatum* and *cicutarium*, *Pyrus aria*, *Sedum rupestre*, *Saxifraga hypnoides*, *Hieracium murorum*. On the marshes of the level and the hill country occur such ordinary bog plants as *Menyanthes trifoliata*, *Anagallis tenella*, *Narthecium ossifragum*. The peat swamps and ditches at Wedmore contain *Andromeda polifolia* and *Utricularia vulgaris*, while *Comarum palustre* is said to grow near Axbridge. Ferns are very abundant among the hollows of the cliffs, the most beautiful and valuable being *Polypodium calcareum*, which will ere long share the impending doom of *Dianthus caesius* (and from a similar cause), unless a powerful hand can avert its fate. The other ferns of the cliffs are *Asplenium Ruta-muraria* and *trichomanes*, *Athyrium filix femina*, *Ceterach officinarum*, *Cystopteris fragilis*, *Scolopendrium vulgare*, *lobatum* and *crispum*, with the commoner forms of *Polypodium*, *Polystichum*, and *Pteris*. *Osmunda regalis* is also occasionally found. It is right to add, that Mr Stevens' little work on Cheddar has been of material assistance in supplying us with this list of the more striking Cheddar plants (several of which want of time prevented us from personally examining), and to the same book we are indebted for sundry facts mentioned in our paper.

At the close of the paper, J. G. Grenfell, Esq., made some interesting remarks on the geology of the Cheddar district.

The President then read the following interesting letter, which he had received from the venerable Professor Sedgwick of Cambridge, along with a large and splendid collection of fossils for the College Museum :—

'CAMBRIDGE, *April* 27, 1871.

'MY DEAR SIR,—I have stupidly lost or mislaid your letter; but I remember the purport of it. You gently smote me—not with a smart rap of your ferrule, but with a Laputan flapper, to rouse my slumbering memory—for not having performed an *old promise* of fossils for your College Museum. I lost no time in giving an order to my assistant to keep a good look-out for duplicates, while the arrangements in the Museum of the University were going on. The work could not be done in a day: it really required time and watching. And, as a forfeit for my delay, or more truly, as a mark of my good will towards your College, I have at my own cost made considerable additions to the duplicates. Clifton has a very dear place in my heart's memory, and I wish all honour and good speed to it. So I now send you 440 species of fossils, and 1100 specimens. They are named, and some of them are mounted, so as to be ready for their place in your College Museum. Two of my assistants have taken great pains in doing their work effectually. Not only the *name* and *species*, but the *localities* and *formations* are marked. So when the specimens are laid down in their true order of supraposition, they will enable any studious boy, who has any elementary works on geology (such as the works of Professor Phillips and Professor Jukes, or the last work—indeed, any of the works—of Sir Charles Lyell), to read them with pleasure and profit, and learn to find his way among the mazes of geology.

'The Tertiary series I send is the best. The Cretaceous has some good things in it under that name, including the Upper and Lower Greensand and the Gault. I have sent no Carboniferous Limestone fossils, because you are living upon rocks which swarm with them, and of the older Palæozoic duplicates I have not many to spare. If any of the boys pick up specimens from the great Clifton limestone (the Carboniferous), they may easily get them named by the curator of your (Bristol) Public Museum, in which there is, by the way, a very noble collection.

'I have made my old and irritable eyes very angry with me for sending such a long letter. Accept my heartfelt good wishes, and with them an old man's blessing, for all the Members, young and old, of your beautiful College.—Very faithfully yours,

ADAM SEDGWICK.'

'*P.S.*—I learnt my first practical lesson in Geology at Clifton, under the guidance of my late well-loved and honoured friend Dean Conybeare.'

A cordial vote of thanks to Mr Sedgwick, proposed by the President and seconded by J. Heath, was unanimously passed. It was further announced that Professor Church had consented to read a paper at an early meeting of the Society, and that A. Cruttwell, Esq., O.C., had contributed a guinea to the funds, to be spent, at the discretion of the Committee, in the interests of the Society.

Visitors having withdrawn, an election of ordinary members then took place. There were eighteen candidates for five vacancies. The following gentlemen were elected :—R. B. DON, T. LANG, T. RANKIN, R. L. MURRAY, J. VAUGHAN.

MEETING, May 26, 1871.

The President in the Chair.

The second meeting for the term was held on 26th May. There were sixty-two members and visitors present.

The following donations to the Museum and Garden were announced by the President: a Tree Wasp's Nest (*Vespa Britannica*), by Miss Richardson; a Rough-Legged Falcon (*Archibutio lagopus*), by J. Heath; a collection of Beetles, by J. F. M. H. Stone; some Plants by D. H. Walsh; a number of Scientific Books for the Library, by F. F. Tuckett, Esq., Hon. Mem.

The Rev. J. Greene exhibited a fine (bred) specimen of the rare *Deilephila Galii* (the scarce spotted Hawkmoth), and also its pupa case. The larva was found last September on Durdham Down, by J. Chamberlaine, Esq., O.C., and the perfect insect emerged in April 1871.

J. C. Prinsep then gave a lecture on 'Heraldry,' and Mr Greene and the President added some remarks at the close.

R. W. Wilson read the following paper on

THE CHURCH OF ST MARY REDCLIFFE, BRISTOL.

St Mary Redcliffe Church is a subject which ought to have some interest not only for the antiquarian part of our Society, but also for the whole of us. It has long been classed as one of the marvels of Bristol. Chatterton, 'Bristowe's wondrous boy's' connection with it, is one of the most prominent features in the unfortunate poet's short life, and this lends it additional interest. It was in St Mary's that Chatterton professed to have discovered his forged MSS. It was in St Mary's that he used to loiter during his play hours, and dream of Bristol in her early days and greatest prosperity, when the city of Bristol actually had a small fleet on the high seas to protect her commerce, and when merchants grew so wealthy that they could easily afford to live in Bristol like small princes, each with his little court of dependants round him. The 'boy-poet' himself says of the Church:—

> 'Stay curyous traveller and pass not bye,
> Until this festive pile astound thine eye—
> Thou seest this maystrie of a human hande,
> The pride of Bristowe and the Westerne lande;
> Well maiest thou be astounde, but view it well,
> Go not from hence before thou see thy fill,
> And learn the buylder's vertues and his name.'

Since the foundation of St Mary Redcliffe Church times have changed very much, and by the change Bristol, I think, has not benefited. In few other parts of the world has the antiquarian such opportunities of pursuing his study as in Bristol; and in Bristol I am sure that the first place to attract his attention would be St Mary Redcliffe Church.

I cannot profess to describe the church to you exactly and in detail, but I will say a little about its principal parts, and the chief objects to be seen there. There is much uncertainty as to the actual founder of St Mary Redcliffe, some people thinking that it was Sir Simon de Burton, others that it was William Canynges. The evidence, however, shows that in all probability De Burton actually founded the church, and Canynges completed it, and gave to it the splendour and beauty which one admires so much at the present day. Taking this view of the case, the evidence shows that Sir Simon de Burton founded the church in the year 1292; but though actually begun then, the body of the church was not built till the year 1377, nearly a century later. In the year 1377 William Canynges, senior, completed the body of the church, and thus finished what De Burton had begun. De Burton and Canynges were both of them famous men in their times. They were each five times Mayor of Bristol, which shows the high rank they must have held among their brother merchants. There is evidence regarding the dates in some wills which contain allusions to the state of the church,—money being left "for the fabric, and towards repairing the Church of Redcliffe." In the year 1445, the steeple was knocked down by lightning, and as it fell on part of the church, great harm was done; 'but,' as an old MS. observes, 'by the good devotion of Mr William Canynges it was re-edified, to his everlasting praise.' Many people believe that the steeple was never knocked down; but it is certainly distinctly stated in the MSS., from which nearly all the history that we know of the church is derived, so that, if we are to believe the rest, I think we are bound to accept this also.

The north porch is the finest and oldest part of the church. Its architecture is of the style known as Early English. The Early English style was at its best in the thirteenth and fourteenth centuries, so we may safely ascribe the north porch to William Canynges, senior, sometime during Edward III.'s reign, between the years 1327 and 1377. We know that in the year 1377—the year in which Edward died—the church was finished, so the north porch was probably built during the latter part of the reign. The architecture of the north porch is wonderful; each part is a study in itself. Every stone in it is elaborately perfect. All the tracing of the ceiling and carving is exquisitely done. This part of the

church was the place where Chatterton could usually be found during his spare hours.

The church has three chief entrances,—by the north and south porches, and by the large doors in the middle of the west side. The one most used now is the south porch entrance. Just inside it, and nearly over the door, there is a block of wood with a curious old sword carved on it. The sword was the property of Sir Robert Yeamans, who was Mayor of Bristol in the year 1669. In various parts of the church are fragments of old stone coffins. Time, however, has worn them away so much, that the inscriptions are illegible. This does not matter much, as coffins of this description are not uncommon in connection with old cathedrals or churches throughout England. I think you will nearly all remember having seen old stone coffins at any ecclesiastical ruins you may have been to. Of course, some people have pretended to know all about the coffins, and some will almost tell you even the histories of their inhabitants, but they have no ground for their stories but their own fertile imaginations. I think the most important office of archæology is to detect old mistakes and prevent their perpetuation by tradition of people who are either too simple or too lazy, and who, knowing but little themselves, take for fact anything connected with their subject that they can find in print. In connection with St Mary Redcliffe Church, there is a great deal of tradition which is entirely untrustworthy, but as the mistakes have been perpetuated through centuries, it is nearly impossible to detect them. We all know what extravagant stories spring up in connection with nearly all famous places. When we visit any famous old ruin, we usually accept the guide's version of its history, minus about fifty per cent.

On the wall facing the south entrance is a monument in the shape of a white marble scroll on a grey slab, with an open Bible carved above. On the Bible are inscribed two texts taken from the Psalms, and on a shield at the base there is inscribed, 'Nunquam nisi honorificentissime'—never unless most honourably. With the motto are engraved the arms and crest of Sir Francis Freeling. Sir Francis was quite worthy of the monument which his children raised to him. His father kept a small confectioner's shop on Redcliffe Hill. He went to one of the smaller Bristol Grammar Schools, and on leaving it became a servant in the Bristol Post Office. Stage by stage, for more than half a century, he mounted up higher till he reached the position of secretary to the General Post Office. George IV. created him a baronet in the year 1825, and in the course of the next year he died at his house in London. Near his monument is another to Sir William Penn, father of William Penn, the founder of Pennsylvania. William

Penn, the father, distinguished himself in the navy, and was knighted for his services. After his death his body lay for some time in state in the Bristol Guildhall, from whence it was taken to Redcliffe Church. The old Admiral's armour is still to be seen at the church.

We now come to the tomb of William Canynges and his wife. Over the grave is a slab of stone with the effigies of Canynges and his wife carved on it. Canynges is carved in long robes of office, from his being Mayor of Bristol, I suppose. The female figure is that of a woman dressed in the ordinary old-fashioned way. A remarkable circumstance in connection with the tomb is, that Canynges himself had it placed in its present position before he died. At the back of the tomb there are several inscriptions,—one giving the chief facts of his life, another the names and tonnage of his ships, and a third is an epitaph recording his virtues.

The first inscription is as follows :—

'William Canning, ye richest merchant of ye towne of Bristowe, afterwards chosen five times Mayor of ye said towne, for the good of the Commonwealth of the same : he was in order of priesthood seven years, and afterwards Dean of Westbury, and died the 7th of November 1474 ; which said William did build within the said town of Westbury, a college (with his canons), and the said William did maintain by space of eight years, eight hundred handy craftsmen, besides carpenters and masons, each day one hundred men. Besides King Edward the IV. had of the said William three thousand marks for his Peace to be had in 2470 tons of shipping.'

Next comes a list of the ships with their tonnage. The largest was one of 900 tons. One was named Mary Canynges, after Canynge's wife Mary. Another was named the Mary Redcliffe, after the church that Canynges loved so well.

The epitaph is as follows :—

'No age, no time, can wear out well-worn fame,
The stones themselves a stately work doth show ;
From senseless grave we ground may men's good name,
And noble minds by ventrous deeds we know.
A lanterne cleer sets forth a candele light,
A worthy act declares a worthy wight ;
The buildings rare, that you may here behold,
To shrine his bones deserves a tombe of gold,
The famous fabricke which he here hath donne,
Shines in its sphere as glorious as the sonne ;
What needs more words, the future world he sought,
And set the pride and pomp of this at nought.
Heaven was his aim, let heaven be still his station,
That leaves such work for others' imitation.'

I cannot say much for the poetry of the epitaph, but knowing the general character of epitaphs, I don't think we look to them for much.

Of William Canynges we do not know much. We know somewhat of his wealth, which was very great. In his private life we know that he was much liked by his dependants, and in public his being repeatedly mayor shows how popular he was. There is a tradition about him, that on his wife's death he became a priest to avoid marrying again, as the king was very anxious that he should do so, and had, in fact, selected the lady for him. He had a splendid house in Redcliffe Street. A little of it now remains intact, but most of it has been much changed since his day. One room especially is very interesting, and is quite worth a visit. The house is occupied by Mr Jefferies, a bookseller, to whom much praise is due for the great care which he takes so as to disturb as little as possible the antiquarian remains.

Around Canynge's tomb were several others, chiefly his servants' burial-places. One of them tradition assigns to his purse-bearer; another bears an inscription informing us that John Blecker, *pandoxator*, lies beneath. *Pandoxator* is translated brewer,—but how the word means that, or whence it is derived, I don't know; I give it on the guide-book's authority.

Near Canynges and his dependants' tombs is a monument erected by subscription to Dr Nathaniel Bridges, who was clergyman of the parish for many years. There is a long scroll below, setting forth his estimable qualities, and below this again is the following epitaph:—

> 'Marble will moulder, monuments decay,
> Time sweeps memorials from the earth away;
> But lasting records are of Bridges given,
> The date eternity, the archives heaven.
> There living tablets with his worth engraved,
> Stand forth for ever in the souls he saved.'

This is near the largest porch, and about it I must now say a few words. Over the porch is a small room, once called the 'Treasury House.' This is where Chatterton professed to find the MS. which he ascribed to Rowley. In this room used to be several large chests, one of which was called Mr Canynges' coffre. It was firmly locked, and there were six keys to it. In course of time all the keys were lost, and in the year 1727 it became necessary to burst open the box, and consequently the documents lay scattered about the room. Different people used to help themselves freely to the papers, and among others Chatterton's father, who had free access to the room, took a fair share. In this way Chatterton, seeing the old parchments lying about at home, came to imitate them, and when he had far excelled the originals, he was induced to say that he found them in Mr Canynges' coffre, to give them the smack of antiquity which their language required.

St Mary Redcliffe Church suffered much during the Commonwealth. The Bristol mob, always an excitable one, at that time lost all command of itself, and caused damage to an enormous amount among the different churches that existed then, especially to those of them whose architecture made any claim to 'the beautiful.'

A great deal has been done during the last twenty years to improve the old church, which would probably have been a ruin by this time had not some energetic Bristolians come to its rescue; even yet much is to be done to put it in such a position as it ought to be in.

There are many old documents connected with the church. I make a short extract from one. It is from a memorandum of stage furniture given to the church by Mr Canynges to act a mystery play with.

Item.—Heven, made of timbre and stained clothes.
Item.—Helle, made of timbre and iron work, with devils, the number thirteen.
Item.—Four pair of angels wings for four angels, made of timbre and well paynted.
Item.—Longing to the four angels four chevelers.

Chevelers were wigs, or heads of hair, I suppose derived from the French.

I think I have now mentioned the chief objects, as they struck me during several visits I have paid to St Mary's. I cannot hope to have described the church in such a way as to picture it to those who have not been there, but I hope I have said enough to induce some who have not seen it to visit it.

Some important facts were added to this paper by the President, Messrs Prinsep, T. H. Warren, J. Stone, S. Leonard, and R. Bamford.

Vistors having withdrawn, the President announced that the opening of the Museum would take place on the 17th June, and he expressed his hope that it would be possible to celebrate the event by a Conversazione. He suggested the appointment of five persons to act with the Society's Committee in making such arrangements as would be necessary for the occasion. In compliance with the President's suggestion, the following gentlemen were accordingly elected :—R. B. Don, J. Heath, W. A. Smith, D. H. Walsh, W. Claxton.

MEETING, June 2, 1871.

The President in the Chair.

The third meeting for the term was held on 2d June. Fifty-four members and visitors were present.

J. G. Grenfell, Esq., read an interesting paper on 'The Geological Section at Portishead,' and he exhibited diagrams of the strata, together with several specimens of the rocks and fossils collected by the members of the Section.

C. T. Blanshard (who was assisted in his experiments by J. F. M. H. Stone) then read the following paper on

GUN COTTON.

I. Before I say anything about gun-cotton itself, I will shortly go through the principle upon which the explosive property, which it and bodies like it possess, depends. Nearly all the compounds of nitrogen are unstable, or in other words, readily split up into the elements from which they were originally composed; we see examples of this readiness of such compounds to decompose, in decaying *animal* matter, which always contains nitrogen—in those dangerously explosive substances formed by the union of nitrogen with the so-called 'halogens,' bromine, iodine, *and particularly* the gaseous chlorine. In these three cases the element nitrogen is so very loosely bound, so to speak, to the halogen elements, that the slightest increase of temperature, or even mere friction, is sufficient to make them fly asunder. Again, other instances of the feeble affinity that nitrogen has for other bodies, are the *nitrates*, and products obtained from them, all of which contain oxygen and nitrogen in combination. You know that when nitric acid is distilled (by acting on a *nitrate* with sulphuric acid), red fumes of lower oxides of nitrogen come over with it; in fact, nitric acid cannot even be raised to its boiling point without partial decomposition. As to the products formed by the action of nitric acid on *organic* substances, or compounds of *carbon*, which have been termed 'nitro-substitution products' (with which we have more particularly to do this evening), they all contain the group of atoms, NO_2, in various proportions. Such a group of atoms as this, which enters into combination with bodies, expelling from them a certain amount of *hydrogen*, or it may be some other element, and taking the place of the expelled element, is called a *compound radicle;* thus the compound radicle NO_2, that takes the place of the hydrogen

which it expels from organic bodies, acts just like an element in building up fresh compounds. However, these compounds that have in them the *radicle* NO_2 (which are easily formed, and can be produced by the action of nitric acid on a great many substances, as woody fibre, carbolic acid, glycerine, &c.), are *as* readily, or more so, decomposed again; and thus they constitute many very important explosive bodies. What takes place in exploding all these bodies is very similar, and is exactly like that which takes place in the explosion of gunpowder. If a mixture of nitre (or potassic nitrate), carbon, and sulphur, in certain proportions is heated, struck, or if the adhesion of its atoms be otherwise disturbed, the nitrogen and the oxygen of the molecule, NO_2, which I spoke of before, suddenly fly apart; the oxygen being thus set at liberty, or being, as it is called, in a nascent condition, immediately combines with and oxidises all the other elements in the substance so disturbed, and forms with all of them new *gaseous* products; these gases, carbonic acid from the carbon burned, steam from the hydrogen, and free nitrogen, also a gas, being thus instantaneously formed out of a substance which the moment before was either liquid (as nitro-glycerine), or solid (as gun-cotton), and occupied therefore a far less space, now tend to occupy, and will occupy, however much they are compressed or held back, an immensely greater volume: there results, therefore, an explosion, produced by the concussion of the pent-up and heated gases on the air around them.

Some of these nitro-substitution products, as they are called, are well known, as gun-cotton (nitrocellulose), and nitro-glycerine; others, not so well known as nitrogen compounds, are Picric acid, which explodes on contact with ozone (as I learnt from Ogle's excellent compilation on that active form of oxygen), and again, fulminic acid, both of them not known in the acid form, but only in the salts called fulminates, as fulminating silver and gold—two very dangerous bodies—and fulminating mercury, not quite so explosive, from which percussion-caps are manufactured.

II. I said before that the halogen compounds with N ($N Cl_3$, NI_3, NBr_3) were very explosive, and I have here some iodide of nitrogen, the least dangerous of the three, which shows well how feebly and loosely nitrogen is united with these elements, for even on mere percussion, or at any rate by a slight heat, it explodes with great violence. (*Experiment*).

2. The reason why the *iodide* of nitrogen is the least dangerous of the three, seems to be that, in this case, where nitrogen is in union with a solid (iodine), the products of the decomposition which results from exploding it, are for the most part solid, and so do not expand to a much greater bulk; while the products of

decomposed chloride and bromide of nitrogen, being all gaseous, expand much more, and so produce a louder report, and do more damage.

When we turn our attention to gun-cotton and its allied substances, we see that their explosive properties are owing to a different cause than mere *disunion* of atoms, as is the case in iodide of nitrogen, for it is the oxygen which they contain, ready to be liberated at any time from the nitrogen, that directly on being set free forms new gaseous products, occupying a much greater bulk.

Since oxygen is formed in such great quantities from the substance itself, there is no need, as in the combustion of paper, wood, &c., for the presence of the oxygen of the air. So gun-cotton, like gunpowder, can be burnt in a closed space free from air, or in an atmosphere incapable of acting on it, as *nitrogen*, or carbonic acid. (*Experiment.*)

Nitroglycerine, which is glycerine with three atoms of its hydrogen replaced by three molecules of the radicle NO_2, is used for blasting rocks, and is ignited by an iron wire passing through it, when enclosed in a strong case, and connected at each end with a copper wire from either pole of a voltaic battery. This iron wire, being a less perfect conductor of electricity than the copper wire, causes some of the electricity to be transformed into a different kind of energy, viz., heat, and the nitroglycerine is ignited and explodes.

Gun-cotton, as its name implies, has lately come into use for guns and cannons as a substitute for gunpowder.

Gun-cotton is manufactured on a large scale by acting on cotton-wool (previously cleansed from grease by boiling with soda) with a mixture of strong nitric and sulphuric acids: the sulphuric acid is necessary for taking up all the superfluous water of the nitric acid, and thus the cotton-wool is kept continually exposed to the nitric acid in its strongest form, when deprived of its water. After a certain time, from a quarter to half an hour, the cotton-wool has taken up as much NO_2 as it can, and is converted into the highest form of gun-cotton: I say the *highest form*, because there are many lower nitrous compounds of cotton, or cellulose, which mixed together constitute *collodion*, a substance used in photography, and soluble in a mixture of alcohol and ether, whilst the highest form of nitrocellulose (represented by $[C_{18}\ H_{21}\ (NO_2)_9\ O_{15}]$) is quite insoluble in the mixture. (*Experiment.*)

The gun-cotton is next washed well in a stream of running water, pulled to pieces, and thrown on to the cooper hooks of a centrifugal machine, where by an action like that of drying a mop by twirling it round, the gun-cotton parts with most of its mois-

ture : it is then dried in a warm room, and closely packed up, to keep it dry, in earthenware jars, ready for use.

To make it on a small scale it is best to distil one's own nitric acid, from a mixture of equal parts of the strongest sulphuric acid and dry saltpetre : *then* you obtain the nitric acid strong, and you can easily tell that it is so by its becoming *hardly at all* warm, when mixed with an equal volume of sulphuric acid. The ordinary "strong" nitric acid becomes quite hot when mixed with sulphuric acid. Into this mixture of nitric and sulphuric acid put the cotton-wool to be made into gun-cotton, and leave it standing for a quarter of an hour. Take it out then, and wash it well by stirring it about in a beaker of cold water, pulling it apart well and pouring more water over it, to get rid of every trace of the acid, especially sulphuric acid, which, if left in the gun-cotton after it is made, will decompose it again into ordinary cotton, and thus make it useless. The cotton must be then well dried, by squeezing it first in a cloth, and afterwards between blotting paper, and finally drying it in the sun or in a warm room.

Of gun-cotton, thus made, I have some here which I shall use in my experiments. It ought (1) to dissolve in strong sulphuric acid without blackening, as it would do if changed cotton were present ; (2) it should be insoluble in a mixture of ether and alcohol. (*Experiment.*)

A temperature even below red heat is sufficient for igniting gun-cotton, especially if it be spread out, when the flame spreads much more quickly through it. (*Experiments.*)*

Gun-cotton, when ignited, decomposes so speedily, that the flame throughout appears instantaneous. (*Experiment.*)

This flame, being so suddenly produced and so quickly over, is capable of giving out very little heat, and, indeed, it is said that one hundred charges of gun-cotton fired in a gun do not heat the gun so much even as thirty rounds of powder. The small heat given off by inflamed nitrocellulose is easily shown. (*Experiment.*) † However, if the gun-cotton be at all damp, as it is apt to become, being very hygroscopic, it will, when placed on the hand with gunpowder and ignited, not only set fire to the powder, but also burn the hand. (*Experiment with damp gun-cotton.*)

When gun-cotton is burnt in the air, unconfined, an imperfect combustion only results, and the poisonous substance cyanogen, and also a little prussic acid (formed by the union of water with

* (1.) Nitrocellulose was lighted with a spark and an ignited wire. (2.) Gunpowder saturated with Greek fire, was shown not to ignite ; while some gun-cotton ignited under the same circumstances.

† (1). Gun-cotton did not communicate its flame to gunpowder. (2.) It was ignited on the hand without burning it, or even giving off much warmth.

cyanogen) are produced. This formerly led to the notion that gun-cotton would be dangerous to employ in blasting, because it would have a prejudical effect on the miners. However, by further experiments it was found that, when confined, it does not produce cyanogen as it does when burning freely in air, but it undergoes complete combustion, so that the nitrogen of the cyanogen (CN) passes off free, and the carbon is oxydised to carbonic oxide (CO) or even the higher oxide, carbonic acid (CO_2). These latter bodies are not nearly so dangerous, especially the last mentioned—carbonic acid.

As gun-cotton will burn equally well when air is excluded, it can, like gunpowder, be employed in torpedoes, which are so much used for blowing up vessels. To form them, iron cylinders are used, closed at both ends, and filled with gun-cotton, or nitro-glycerine: through the gun-cotton in the cylinder (as in these models here, made of gutta-percha) a thin iron wire passes, which is turned round the cotton, in order to impart all the heat possible to it at once: attached to each end of the iron wire, and passing through either side of the torpedo, is a long insulated copper wire, reaching to the battery of the experimenter, either on land or on board ship. When a ship passes over one of the torpedoes, the owner of the electric battery sends an impulse along the copper wires, which electric shock, as soon as it arrives at the iron wire, an inferior conductor to copper (just as I said before with regard to blasting rocks), becomes partially converted into heat, and igniting the gun-cotton, bursts the torpedo, and blows up the vessel. (*Experiment with gutta-percha torpedoes.*)

As gun-cotton ignites much more readily, and more quickly than powder, and, also, as all the products of its combustion are gaseous, it is naturally much more powerful than gunpowder, weight for weight. (*Experiment with pistols and bullets, charged with an equal weight each of powder and cotton. The superior power of the gun-cotton was thus demonstrated.*)

Cartridges made of nitrocellulose, for cannon, &c., are always composed of gun-cotton *diluted* with ordinary cotton, for two reasons—firstly, the gun-cotton burns more quickly when kept apart: if compressed tightly by itself it sometimes only smoulders (*experiment*);—and secondly, in order to distribute the gun-cotton through a greater part of the fire-arm, and thus avoid a too sudden action, which might burst it.

The numerous experiments shown by Blanshard and Stone were very successful, and on the motion of J. G. Grenfell, Esq., a vote of thanks was passed to them for the great trouble they had taken in preparing them.

The President then announced that the Committee had decided to devote Mr Cruttwell's donation to the purchase of a medal, which should be given at Midsummer for the best collection of Natural History objects collected during the present term by any member of the Society. He further stated that, as this arrangement might seem to exclude members of the Physical and Chemical sections from the competition, Mr Greene and himself would be happy to offer another medal for the best essay on 'The Spectrum.'

MEETING, JUNE 9, 1871.

The PRESIDENT in the Chair.

The fourth meeting for the term was held on 9th June. Fifty-two members and visitors were present.

The following donations to the Museum were acknowledged:—A collection of coins by J. I. Fox, Esq., Cor. Mem.; the skull of a horse, by Mr Wheeler, Triangle, Clifton; five ancient axe-heads from Ireland, by M. J. Barrington-Ward, Esq., President.

The Rev. R. B. Poole, M.A., was declared to have been elected an Honorary Member of the Society.

J. ALLEN read the first part of a paper on 'Volcanoes.' When completed this paper will appear in the 'Transactions.'

P. R. OGLE next read a paper (of which the following is an abstract) on

THE ATMOSPHERE.

The author opened his paper by drawing attention to the former universal application of the term 'air' to any gaseous body, and its present restriction to the atmosphere. With regard to its physical constitution, he first noticed the fact of its rotation with the earth, and proceeded to discuss its extent, showing that, in all probability, there is a limit to the atmosphere 'as definite as that of the waters of the ocean' (*Miller*); he then touched briefly upon the fundamental cause of motion in the air; the atmospheric tides and waves; the land and sea breezes, &c. Next passing on to the subject of the trade-winds, he considered them more in detail; this brought under notice the calms, monsoons, simooms, siroccos, tornadoes, typhoons, cyclones, hurricanes, &c., and the subject was closed with an account of the storms of Clifton. He then entered upon a notice of the pressure of the atmosphere, the barometer, and the measure-

ment of height by its means; the decrease of density due to elevation, and the reduction of temperature caused by expansion; and, with a description and explanation of the colour of the atmosphere, and some statistics regarding its weight, specific gravity, specific heat, &c., the first part of the paper was concluded. In considering its chemical constitution, he noticed the ancient idea of the atmosphere's elemental character, and sketched the early history of the discovery of its compound nature, the grave doubts entertained as to whether its constituents were simply mechanically mixed or chemically combined, owing to the remarkable constancy in composition. The normal composition was then given, and the various functions of each of these pointed out: oxygen, the supporter of respiration and combustion; nitrogen, a dilutant of its more active associate; carbonic acid, nourishing the vegetable kingdom, the oxygen being at the same time set free for the support of animal life; aqueous vapour, the source of dew, fog, cloud, rain, snow, and hail. The following is an extract:—

'It is but a fog—a large aggregate of vesicular and solid particles of water, in the far depths of the air, that produces what we call clouds; which as they loom darkly o'er this world of ours, in all their fantastic shapes, mysterious, terrible, seem to bar our way to the bright heaven they hide from our view; or again, when the noonday sun lights up their thousand forms with brilliancy divine; when the crimson glow of the evening transforms them into a mass of blazing radiance, they seem

> "As though an angel host in upward flight
> Had left their mantles floating in mid-air."

Wonder upon wonder meets our eye; now we see among their giant forms a snowy mountain hanging in mid-air; now a toppling crag with dark seared sides; now again a summer landscape fading away in the far distance, so sweet, so beautiful, that we can almost fancy it to be the path which leads us upward to our God above, when once the icy river of death be past; or again, a depth of impenetrable blackness, a very chaos, that might fitly be the portals to the domains of the arch-fiend himself.'

The abnormal constituents of the air were then briefly noticed: organic matter and germs, the propagators of disease; nitric acid and ammonia, the chief source of nitrogen for plants; carburetted and sulphuretted hydrogen, sulphurous and sulphuric acids, the products of the combustion of coal and decomposition of animal matter; selenuretted hydrogen, said to be present in dry-fog; and ozone, the great purifier of the atmosphere by destroying miasmata and organic particles with its powerful oxidizing properties.

After quoting the words of Sir Humphrey Davy on the importance of the study of the occasional and abnormal ingredients, he concluded an able and interesting paper by saying,—

'The consideration of the facts I have laid before you this evening leads us to regard the atmosphere as a huge recipient into which there is a constant flow of volatilized and gaseous bodies, now combined, now separated, now lashed into a mighty tempest, now suffered to lapse into a gentle, languid breeze, or perfect calm; by these transformations each body is purified, renewed, and renovated, and by such modification again fitted to play its part in the great and wondrous processes continually taking place on our every side. In this mighty chaos, then, in this vast laboratory of our universe, there exists an indeterminate mixture of mineral vapours, of vegetable and animal products, of seeds and germs, in fact, a portion of everything, as Lucretius says (*De Rer. Nat.*),

> '"Quodcumque fluit de rebus, id omne
> Aëris in magnum feretur mare."

Numberless chemical processes are carried on in the air, and each constituent of it having played its part and run its course, and having been thereby unfitted for further use, is, by the continual passage of the luminous, the calorific, the actinic, and electric fluids, regenerated, and again emerges as before, ready to take part in the economy of Nature. Surely this must vividly impress us with the majesty and power of the Author of all, and the truth of the saying, "The firmament showeth His handiwork."'

On Mr Ogle's paper Messrs Barrington-Ward and Greene made some observations.

A long discussion respecting the conversazione concluded the business of the meeting.

CONVERSAZIONE, June 17.

The Society held its first 'Conversazione' this evening, on the occasion of the opening of the new Museum and Botanic Garden. The success of the meeting having been far beyond expectation, it has been considered desirable to give a full account of the evening's proceedings in our Transactions, and many who were present will no doubt be glad to have a more permanent record than that afforded in the columns of the newspapers. We are much indebted to the local press for the excellent reports with

which they favoured us, and from them we must of course extract largely.

'On Saturday,' says the *Daily Post* of the 19th June, 'an event took place at Clifton College which will doubtless inaugurate a new era in the history of this important and flourishing institution—namely, the opening of a repository for natural and scientific objects. The idea of establishing a Museum originated with a society in connection with the College, called the 'Clifton College Scientific Society,' which was founded in the middle of the year 1869. Starting with the insignificant roll of eighteen members, the association has grown until it now numbers about seventy ordinary members, in addition to a fair proportion of honorary associates; and it has corresponding members both at Oxford and Cambridge. Some valuable observations having been thrown out in the way of collecting for a Museum by Canon Kingsley, who delivered the inaugural address to the society, the matter of a School Museum was taken up with considerable energy by gentlemen connected with the College, who knew what an important influence the study of natural history was calculated to work. It was decided that the Museum should be essentially a British one, illustrating the natural history and antiquities of our land by good specimens arranged under the departments of zoology, botany, geology, mineralogy, and archæology. An appeal by the committee in quarters where it was likely to be effectual has resulted in the accumulation of a considerable number of useful specimens, as well as a good round sum to meet the expenses entailed by the fitting-up, and to purchase specimens not likely to be procurable from private donors. The project was heartily concurred in by the head-master of the College, the Rev. Prebendary Percival, who erected at his own expense and presented to the College an extensive building, intended for a Library and Museum. It is a well-lighted apartment in the Early English style, 60 feet by 23 feet, and situated on the first floor. It comprises five bays, the lower one being at present used as the secretary's office. The book cases are fitted in between the windows, so as to form a series of recesses annexed to the windows of the room, with a table in each for study. The library is already well-stocked, and contains some 1300 valuable volumes, comprising works of standard authors. The architecture of the Library and Museum is in character with the rest of the College building, the roof being open-timbered, of ornamental construction, with hammer beams, resting on wooden columns. The museum cases are arranged down the centre of the room. The specimens grouped in them, though not extensive, are valuable,

and, so far as they go, complete. The fittings are of polished pine ; and in drawers placed underneath a large case running up the centre of the room, are over a thousand specimens of British minerals. There is also a fine generic collection of shells. At the further wall of the Library a spacious case challenges attention, which contains a small collection of stuffed British birds, that have been presented by various pupils of the school. Perhaps the gem of the whole Museum is the magnificent collection of British butterflies and moths which has been presented by the Rev. Joseph Greene, the treasurer, and contains almost every known specimen of these beautiful winged insects met with in this country. Most of the fossils which the Museum contains are illustrative of the geology of the neighbourhood. We have, of course, only alluded to the principal objects of interest in the Museum ; but all that has been collected can only be regarded in the light of a nucleus of a more pretentious collection. Doubtless a large sphere of usefulness is in store for the Clifton College Scientific Society, as not many schools in England possess such advantages for the study of science. Mr M. J. Barrington-Ward, the president of the Scientific Society, and natural history master in the College, has been appointed curator of the Museum, and the internal arrangements and grouping of the specimens have been carried out under his direction. The charge of its several sections is placed in the hands of sub-curators, selected for the most part from members of the College Scientific Society who may have given special attention to the study of particular branches of science. The fittings, which are of superior character, have been executed by Mr Harris, of Clifton, under the direction of the architect of the College, Mr Hansom.

'Another feature of interest in connection with the College is the formation of a Botanic Garden, to which a waste piece of land at the north end of the College grounds, between the chemical laboratory and the chapel, has been devoted. It contains upwards of 1000 specimens of hardy flowering plants, contributed mainly by the various Royal Botanic Gardens. An arboretum has been furnished by Mr T. Proctor, and there is a rockery which contains a fine assortment of Alpine plants. The plan upon which the garden has been laid out is simple, but well adapted to the purpose for which it is intended—viz., to be a means of study to the pupils of the College. The beds, which are narrow, are arranged in parallel lines, separated from each other by a strip of greensward. They are consequently easy of access. The garden is kept almost wholly in order by the boys.

'The opening of the Museum and Botanic Garden was signalised

by a Conversazione at the College on Saturday evening, which was attended by a large and fashionable company. That part of the College known as "Big School," which adjoins the Museum and Library, was devoted to the entertainment. In these rooms was gathered a superb collection of objects of art, *vertu*, and antiquity, which had been lent by various gentlemen of Clifton. Such rare curiosities are but seldom brought together as found a temporary abiding-place beneath the roof of the College on Saturday, and the interest and delight with which they were inspected by the numerous visitors showed that the treat was highly appreciated. Our space will not permit us to give anything like an enumeration of the treasures. We can only just glance at a few of the leading ones. In the Museum were some valuable cases of animal remains, lent by the Bristol Museum and Library. There were also a number of old Bibles, quaintly illustrated, lent by Mr Francis Fry, of Cotham, which were inspected with considerable interest. Mr W. H. Budgett contributed a number of highly interesting objects. Disposed about the walls of the Museum were some fine photographic views, principally Venetian, lent by Mr Lewis Fry. We also noticed in this room a model of Clifton College as it will be when completed, by Mr Hansom; a fine collection of models of English seals, lent by Mr H. O. Wills; and a number of very rare Elzevir and Aldine volumes, lent by Mr M. J. Barrington-Ward. There were also some remarkable old books, contributed by Mr T. Proctor, which, from their size and weight, possessed little attraction for lovers of "light" literature.

> "Heavy and huge, they fill the world with dread,
> Are much admired, and are but little read."

The lobby, between the Museum and Big School, was embellished with a magnificent collection of large tropical plants and ferns, from the greenhouses of Messrs Joshua Saunders, Lewis Fry, and Walsh. Here, too, were placed, as if in their native woods, some stuffed figures of wild animals, of which a huge gorilla formed the principal attraction. The staircases were also decorated with plants and stuffed birds, in the most profuse manner. The chief pains, however, had been lavished upon "Big School," which presented a brilliant aspect. It had been cleared on purpose for the entertainment, and at one end was a raised platform, which was occupied at intervals during the evening by the members of the College Orpheus Society, under the conductorship of Mr Trimnell. Half the spacious area was given up to the auditorium, the lower end being left to promenaders. Some magnificent specimens of exotic floriculture were disposed about this end of

the room. In the centre was a fine group of plants, in the middle of which was a magnificent overarching palm from the hothouse of Mr Lewis Fry, below which were some striking caladiums, belonging to Mrs Gouldsmith, while several tree ferns stood at the base.

'It should be added that the floral decorations were all executed under the able care of Mr Joshua Saunders, whose splendid collections also furnished very many of the plants exhibited. Up and down the sides of "Big School" ranged stands, which were made the depositories of countless objects of interest. Some powerful microscopes, belonging to Messrs Atchley, W. L. Carpenter, Hatch, Ward, Stone, and Fedden, were scattered through the room, and extensively patronised. A splendid case of Egyptian antiquities, lent by Mr T. Pease, of Henbury, was the object of much admiration. Prominent amongst the valuables we noticed the massive plate belonging to the Corporation of Bristol. Some Indian curiosities, sent in by Lieutenant-Colonel Lambert and Colonel Batten, were inspected closely, and so was a little model illustrative of Professor Wheatstone's wave theory, lent by Mr Exley. Here was also a superb and almost unrivalled collection of British insects belonging to the Rev. J. Greene. Perhaps, however, the greatest art treasure in the building was a small case lent by Mr Lewis Fry, and containing antique timepieces, reliquaries, and snuff-boxes, in precious metal and jewelled. This collection, we understand, has a national reputation, and we were told is valued at nearly £1000. Among a curious collection of dried plants lent by Mr Herbert Thomas was a specimen of the pitcher plant, together with plants gathered from the ruins of Baalbec, Tyre, and Mount Tabor. There was an exquisite miniature Indian ivory car, lent by Mr W. H. Budgett, as well as some articles personally obtained in India by Miss Mary Carpenter. Some beautiful medallions of Italian painters and poets, belonging to Mr T. Proctor, were much admired. The Dowager Lady Mackworth lent several things of great rarity, including a watch which belonged to the ill-fated Anne Boleyn, attached to which was a necklet of Queen Elizabeth. The Japanese bronzes, lent by Mr Joshua Saunders, were very fine, and so were some that belonged to Mr Edlin, Q.C. We have only noticed the principal among the nic-nacs with which the stands were crowded, for their name was legion. There were silver idols from Burmah, a scallop shell carved by the monks of Bethlehem, sponge resembling the human brain, model of the remains of the Arch of Vespasian at Rome, thorns such as were supposed to have been placed on the brow of our Saviour, &c. Some relics of the field of Sedan, lent by Mr Duncan, of Clifton, who was taken prisoner by the Ger-

mans, were viewed with interest. We must not forget some life-like specimens of physical force sent in by Mr Superintendent Handcock, and occupying a position in the middle of the room. We were told they were keeping watch over the valuables. Though hardly necessary in such a company, their presence bore evidence to the great value of the objects exhibited. The walls were crowded with pictures, the gem of which was a splendid Murillo, "The Immaculate Conception," sent in by Lady Harding. Mrs Darling lent a couple of works by Sir Joshua Reynolds, and Mr T. Proctor one by Hopkins, "Pony and Fawns." Lady Mackworth exhibited a portrait of Colonel Sir Digby Mackworth when a boy, painted by Sir Thomas Lawrence. A drawing was pointed out to us as having been the work of Miss Priscilla Fry, of Cotham, and which obtained a prize medal at South Kensington. It was much admired. We noticed, too, some good line engravings belonging to Mr Mann, of Clifton, and about fifty oil paintings by modern artists were lent by Mr Frost, of the Triangle. There were several valuable works hung upon the walls, the property of Mr Lewis Fry; and Mr W. K. Wait contributed an Italian triptych of the 16th century. It would be impossible to enumerate the pictures which were scattered about the walls, which literally blazed with jewels of fine art.'

The following is a tolerably complete list of those who contributed objects for exhibition :—The Corporation of Bristol, the Philosophical Institution, Lady Mackworth and Lady Harding, Mr J. Saunders, Mr Lewis Fry, Mr W. H. Budgett, Mr Wheeler, Triangle, Mr J. Frost, Clare Street, Mr R. Mann, Mr F. H. Poole, Mr F. Fry, Mr T. Pease, of Henbury, Rev. W. James, Miss Carpenter, Mr P. Duncan, jun., Rev. J. Greene, Mr J. D. Wadham, Mr Edlin, Q.C., Mr J. G. Grenfell, Colonel Channer, Mr Herbert Thomas, Mr G. S. Bryant, Mr T. Stuart, Mrs S. Leonard, Col. Boyd, Mr R. M. Bernard, Colonel Lambert, Mr Warren (Pembroke Road), Mr Alderman Proctor, Mr W. K. Wait, Mr J. Stone, Mr J. B. Heath, Rev. F. Armitage, Mr T. H. Warren, Mr Harris, Mr Henry Jenkins, Rev. T. Birfatt, Mr R. B. Don, Mr G. F. M'Corquodale, Mr C. Fisher, Mr Brownlow, Mr M. J. Barrington-Ward, Rev. T. Smith, Mr J. Perry, Mr D. H. Walsh, Mr C. Holmes, Mr Cunliffe, Mr P. Walsh, Rev. J. and Mrs Percival, Mr T. G. Ponton, Mr W. P. King, Mr Hansom, Mr H. M. A. Owen, Mrs L. Thomas, of Begbrook, Professor Campbell, Mr Roscoe, Mrs Wood, Mr Bird, Mr Baddon, Mr Phillips, Mrs Harding, Miss Harris, Mr Carrington, Mr Washborne, Colonel Batten, Mr M. Adey, Mr W. L. Carpenter, Mr Atchley, Mr W. J. Fedden, Mr Hatch, &c.

We will now proceed to glance at the proceedings of the evening. The company began to arrive a little before seven o'clock,

and the rooms were soon filled with a numerous assemblage, comprising the *élite* of the neighbourhood. A continuous stream of visitors set in till the place was almost uncomfortably full, and there must have been fully 700 persons present. The entertainments provided were of a varied character, as the following programme will show :—

7.30. Soldiers' Chorus (*Faust*), "Glory and Love"..... *Gounod.*
7.45. Short Introductory Speech by the Head Master.
8. 0. Glee..... "Maying"..... *Müller.*
8.10. Short Lecture on the Electric Telegraph, by Mr Kerry.
8.25. Glee..... "Soldiers' Love"..... *Kücken.*
Piano Solo..... *Schumann.*
H. Moser.
8.40. Professor Church's Address on "Colour."
9. 0. Glee..... "The Three Chafers"..... *Thrun.*
Duet (*Lily of Killarney*) "The moon has raised"..... *Sir J. Benedict.*
W. Fairbanks and A. Tovey.
9.10. Mr Lant Carpenter's Address on "Deep Sea Dredging."
9.30. Glee..... "Lützow's Wild Chase"..... *Weber.*
Glee..... "Sleep, gentle lady"..... *Sir H. Bishop.*
10. 0. Finale..... "God save the Queen."

The performance of the musical portion of this programme took place on the platform in Big School, and the Head Master's and Professor Church's speeches were also given there. Mr Carpenter's address was delivered in the new Mathematical Classroom, and Mr Kerry's lecture in the Gallery. In the last mentioned place a series of electrical experiments were also given at intervals during the evening, by Messrs Francis Fry and J. M. Hatch. It is almost needless to add that they attracted very large audiences. The apparatus used in these experiments (which were remarkably successful) was most extensive and valuable.

The introductory chorus from Faust having been rendered by the College Orpheus Society in excellent style, the Head Master (Rev. Prebendary Percival) rose, amid much applause, to deliver the speech allotted to him in the programme.—'Two or three days ago,' he said, 'the indefatigable President of the Scientific Society informed him that he was expected to deliver an inaugural address at the Conversazione ; but if other people were impressed with those words as he was, he felt they must expect something more elaborate than he was prepared to give. He intended, however, to keep to his original programme, and to make only a few introductory remarks. On his own behalf, and on that of everybody connected with the College, he begged to tender his thanks, not only for the things which had been sent in, and for the help which had been given, but for that which they valued still more —the kindly feeling of which he took those to be only the signs and tokens. (Hear, hear.) He hardly dared to allude even to the

Corporation of Bristol, who had sent them many things that reminded them of the history, dignity, and good cheer of their great city, nor to the Philosophical Institution, who had gone out of its way to help them in so marked a manner. To one and all, both lenders and helpers, they were really grateful for what they had done on that occasion. He might perhaps be expected, on that, the first time they had made any public use of their Museum and Library, to say a word or two as to their ideas in connection with those matters, and why it was that they laid any special stress upon the fostering of such a thing as a Museum as a kindred part of their institution. There were two reasons why he held it to be important that those things should be developed as parts of any school which intended to be a great or a useful school. One reason was, that hitherto in this country far too little attention had been paid to out-of-school life. They had worked very hard in various ways to educate boys in school, but out of school the life had been allowed to grow very much at hap-hazard. There was no exact or methodical provision made for the growth of character, the moulding of it in any particular direction. That had been one of the great defects of education hitherto. They ought to do more for the cultivation of young people, not merely while they were under education, but through the whole period of their life, because it was during the out-of-school period of early life that the most important influences were brought to bear upon them. Thus it was that so much attention had been paid to such matters as cricket and football, and that boys had been encouraged to organise their life. It was to work out such ideas that they had their debating societies, their literary societies, their botanical gardens, their workshops, and their scientific societies (cheers); and it was part of that work in which those present had been invited to help that night. The whole system of education happened to be changing in their hands just at present; science was the new learning at the present time, and no doubt by-and-by the whole face of education in England would be changed by the new position which science and scientific teaching must take. But new learning required new methods, and they who had anything to do with education were suffering under the influences of tradition. Education hitherto having been chiefly linguistic—those methods which they had inherited for the study of languages would have to be altered, even with the study of languages itself. They learnt few things so thoroughly and really as they ought; and having studied words so long they were content very often when they had arrived at them, without having reached the sense they were intended to indicate. It seemed to him very often that even the study of languages was not worth so much as it used to be.

Everything was now made so easy to the new generation. The order was getting reversed, and whereas boys used to work hard if they wanted to learn anything, and the teachers took it easy, now as to the teachers he was sure they worked exceedingly hard —(cheers)—and he was sometimes induced to think the boys had things made too easy for them. One of the effects of competition was that there was too much hot-house cultivation; and therefore it was very important they should provide such institutions as the museum and the laboratory and the workshop. What they ought to encourage was independent, self-reliant, hard, earnest work. (Applause.) Perhaps they might, all of them, be the better for remembering that instruction was not the same as real education. They might get knowledge and information, but they would not obtain fibre unless they used independent effort. (Hear, hear.) The rev. gentleman continued by saying he did not profess to know what would be the future relation of science to education. But he ventured to say one thing—and that was, whether they were boys and girls at school, or grown-up boys and girls learning the later lessons in the school of life, they should just consider, when they looked around at that infantine Museum, how little they knew of that which they had inherited from the past, and how feeble they were in their attempts to understand the phenomena that were all around them; and if they would learn the further lesson, that the great thing they had to do was to endeavour as far as they could to work honestly and simply; to get at some real knowledge, to do some real work, to cultivate some real desire to get the truth—if they could only look around them in that way, they would go away probably with something more than a desire after the truth—with that reverence which was sometimes wanting in some of them simply because they were so wrapt up in their immediate surroundings as to be unconscious of what was round about them, and of the great mystery of that which lay before them. (Loud cheers.)

At a later period of the evening Professor Church, of the Royal Agricultural College, Cirencester, gave a highly interesting lecture on the nature of colour. Mr Lant Carpenter's address drew together a very large audience, and at the request of the President of the Scientific Society (who occupied the chair), the lecturer very kindly promised to give a further account of his experience during the Atlantic dredging expeditions at an early date. To Messrs Church, Carpenter, and Kerry, the best thanks of the society are due, as their lectures were among the most successful events of the evening. The Orpheus Society also deserve high praise. Their

performance was most brilliant, and elicited the heartiest applause.

The entertainment was brought to a close by the strains of the National Anthem, at the reasonable hour of half-past ten. A half holiday on the following Monday (19th) was very kindly granted by the Head Master, to give the entire school the opportunity of seeing the splendid collections which the Conversazione had been the means of bringing together. The general public attended on the same day in large numbers, and many were thus able to make a more minute inspection of the objects exhibited than had been possible on Saturday evening, owing to the crowded state of the rooms. The Botanic Garden was also visited by a large number of persons, and its trim and well-kept appearance met with general approval, even from the non-scientific.

The Conversazione, from a financial point of view, proved very successful. After all the heavy expenses of the evening had been defrayed, a sum of nearly seventeen pounds remained in hand, the greater portion of which was given to the Museum fund. The committee, under whose management the entire arrangements were made, consisted of the following members :—The President (Mr Barrington-Ward,) Rev. R. B. Poole, Rev. J. Greene, Messrs Joshua Saunders, J. F. M. H. Stone, T. H. Warren, R. F. Brunskill, R. B. Don, J. Heath, R. W. Wilson, W. Claxton, W. A. Smith, and D. H. Walsh.

MEETING, June 23, 1871.

The President in the Chair.

The fifth meeting for the Term was held on 23d June. Fifty-eight members and visitors were present.

The President congratulated the Society on the success of the late Conversazione, and thanked the members of the Committee for the energetic way in which they had assisted him.

A "flying-fox" (*Pteropus rubricollis*) was exhibited to the meeting, presented to the Museum by E. G. and W. E. Money.

The following donations were also acknowledged :—Some stuffed seabirds, by Miss Stone, Bath, and by A. Cruttwell, Cor.

Mem.; one hundred and sixty plants for the Botanic Garden, by Mr John Nelson, Stapleton Nursery; a hedgehog (*Erinaceus Europaeus*), by C. S. Penny.

On the proposition of the Rev. Jos. Greene, the President consented to draw up an account of the Conversazione for the Transactions.

F. H. D. Powell then read the following paper on

MAN.

My intention this evening is merely to call your attention to some of the most important features of this interesting subject, as a full examination of everything belonging to the human species would include nearly all that is curious in nature or interesting and useful in science. Of all the objects which nature presents to our observation, there is none that so powerfully demands our attention; none, indeed, with which it so much concerns us to be intimately acquainted as man. If we admit that he is the only being possessed with reason, there is no other creature which can for a moment be brought into competition with him. Of those writers who treat directly of man, the philosopher and the moralist consider him in the abstract; the geographer describes him as he exists in communities; the historian traces the origin of society, the progress of man in arts, civilisation, refinement, and the changes which have taken place amongst the human species from the ambition of kings, physical causes, and others too numerous to mention; the biographer treats of man as an individual, and exhibits the effects of exalted virtue, eminent abilities, or striking vices. It is the business of the naturalist to describe the external form of man, as it differs from that of other animals.

The natural history of man, in its most comprehensive sense, constitutes a subject of immense extent and endless variety, one, indeed, which would demand a familiar acquaintance with almost the whole circle of human knowledge, and a combination of the most opposite talents and pursuits. But this labour, much too extensive to be executed by any individual, is divided into subordinate branches. The anatomist and physiologist unfold the uses of the corporal mechanism; the surgeon and the physician describe its diseases; the metaphysician and moralist occupy themselves with the functions of mind, and with moral sentiments. It would be somewhat wearisome to take the structure of man in detail, so we will pass on to a more interesting portion of the subject. It has justly been observed, that the human countenance is the mirror of the mind. In the looks of no animal are the expressions of passion painted with such energy, or with such gentle shades

and graduations, as those of man. We know that in certain emotions of the mind the blood rises to the face and produces blushing, and that in others the countenance turns pale. In our climate the natural colour of the face of a man in good health is white, with a lively red suffused on the cheeks. Paleness of the countenance is always a suspicious symptom. The colour which is shaded with black is a sign of melancholy, and constant and universal redness is a proof that the blood is carried with too much impetuosity to the brain. A livid colour is a morbid and dangerous symptom, and that which has a tint of yellow is a sign of jaundice. The colour of the skin is frequently altered by want of sleep and nourishment, and by diseases. But, notwithstanding the general similitude of countenance in nations and families, there is a wonderful diversity of features. No one, however, is at a loss to recollect the person to whom he intends to speak, provided he has once fully seen him. One man has liveliness and gaiety painted in his countenance, and by the cheerfulness of his appearance announces beforehand the character which he is to support in society. The tears which bedew the cheeks of another man excite compassion, even in the most unfeeling heart. Thus, in the face of man are represented the types or symptoms of his moral and physical affections—love, envy, pride, tears, terror, astonishment, anger, horror, sleep, fear, sorrow, compassion, and what is more, even death, and numbers of others of less importance. When the mind is at ease, all the features of the face are in a state of profound tranquillity, and by their proportion, harmony, and union, point out serenity of the thoughts; but when the soul is greatly agitated, the human soul becomes a living canvas, upon which the passions are painted with equal delicacy and energy, and every emotion of the soul is expressed by some features, and every action by some mark. It is in the eyes that the soul is pictured in the strongest colours, and also with the nicest shades.

At his birth man is the most feeble of all animals; he cannot subsist, even for a short period, except by the care of his parents, which he has occasion for during a much longer period than any other animal. It is chiefly by the features of the countenance, and the colour of the skin, that the different varieties of the human species are distinguished. Every zone is more or less marked by its distinctive colour. The black prevails under the equator, and the dark copper colour under the tropics. From the Tropic of Cancer to the 70° of north latitude may be successively discerned the olive, the brown, the fair, and the sanguine complexion; and of each of these there are several tints and shades. Does not this uniformity of effect indicate an influence

of climate, which, under the same circumstances, will always produce the same, or nearly the same, results?

Possibly there is no part of the natural history of man more interesting than that which describes the progressive advancement and decay of human life from the cradle to the grave. Nothing exhibits such a striking picture of our weakness as the condition of an infant immediately after birth. Incapable of employing its organs, it requires assistance of every kind. In the first moment of existence it presents an image of pain and misery, and is weaker and more helpless than the young of any other animal. The infant now respires, and begins to utter sounds and cries. Most animals are blind for some days after their birth. Infants behold light the moment they come into the world. A new-born child cannot distinguish objects, because it is incapable of fixing its eyes upon them. About the end of forty days the infant begins to hear and smile. About the age of seven months children begin to cut their teeth, and these do not come without pain. The pulse in children is much quicker than in adults, and from this it may certainly be inferred that the internal heat is in the same proportion greater. Till three years of age the life of a child is exceedingly precarious. In two or three years it becomes more certain, and at seven years of age a child has a better chance of living, it is said, than at any other period of life. The period of infancy is followed by boyhood and adolescence. This commences at the age of twelve or fourteen, and usually ends about thirty. The body having acquired its full height during the period of boyhood, and its full dimensions in adolescence, remains for some years in the same state before it begins to decay. This is the period of manhood, which extends over a space of about twenty years, from the age of thirty or thirty-five to that of fifty or fifty-five. Physiologists give the name of old age to that period of life which commences immediately after the age of manhood and ends at death; and they distinguish gray old age from that of decrepitude. But it has been thought better not to give such an extensive signification to the word. Men are not old at the age of fifty or fifty-five, and though the body may give signs of decay, we can hardly admit that it has arrived at the period of old age. Decline begins from forty to forty-five or sixty to sixty-five years of age. At this time of life the diminution of fat is the cause of those wrinkles which begin to appear in the face and in other parts of the body. The skin not being supported by the same quantity of fat, and being incapable of contracting for want of elasticity, sinks down and forms folds. In the decline of life a remarkable change takes place in vision. At sixty or sixty-five years of age the signs of decline become more and more visible,

and indicate old age. This period commonly extends to the age of seventy, sometimes to seventy-five, but seldom to eighty. The eyes and the stomach then become weaker and weaker, leanness increases the number of wrinkles, the hair becomes white, and the strength and memory begin to fail. After seventy, or at most eighty, years of age, the life of man is, as the royal bard of Israel observed, nothing but labour and sorrow. Some men of strong constitutions enjoy old age for a long time without decrepitude, but such instances are very uncommon. Infirmities and weakness continually increase, and at length death closes the scene. The signs which announce the approaching dissolution of the body are humiliating to the pride of man. The memory fails, the fibres become hard, and the nerves blunted; deafness and blindness take place; the appetite fails; the necessity of eating, and more frequently that of drinking, is felt; after the teeth have fallen out, mastication is imperfectly performed, and the digestion is bad; the lips shrink inwards; the edges of the jaws can no longer approach each other; and the muscles of the lower jaw become so weak that they are unable to raise and support it. The decrepit wretch is unable to continue erect; he is obliged to remain on a seat, or lie stretched in his bed. The circulation of the blood becomes slower; the strokes of the pulse become fewer and feebler; respiration is slower; the body loses its heat; the circulation of the blood ceases; death follows, and the dream of life is at an end.

At the conclusion of Powell's paper, an animated discussion took place with respect to the longevity of the human race. The Rev. J. Greene, and Messrs Barrington-Ward, Ogle, Wilson, R. Bamford, and J. Stone, joined in the debate. The President stated that he had been collecting accounts of cases in which people had died at one hundred years of age or upwards. He requested members of the Society to obtain for him any authentic evidence on the subject which might come before their notice.

A. Cruttwell, Esq., O.C., Cardiff (a corresponding member of the Society), next read an interesting paper on

THE COAL-FIELD OF SOUTH WALES.

The coal-field of South Wales has long been one of the most famous in the world. It is celebrated for two reasons—first, its compactness; and secondly, its steam measures. The steam measures or smokeless coal are the lowest seams in the series. Their northern outcrop is just north of Aberdare; from thence they dip

rapidly to the south, the amount of dip being about four inches in the yard, till, at Navigation Colliery (near Quaker's Yard), about six miles south of Merthyr Tydvil, they are several hundred feet below the surface. Indeed, after this spot, they run to such a depth that they are perfectly unworkable, and would be lost for ever, but that, luckily for commerce, an 'anticlinal' throws them up again. They then dip again to the south, and rise to their southern outcrop near Walnut-Tree Bridge, only seven miles north of Cardiff. Thus, in their course from north to south, they describe two synclinals and one anticlinal. They also occur in the Rhondda Valley.

Let us first glance at the general configuration of this coal-field. In order to do so we ought to see what different formations occur in its neighbourhood. The coal-measures (as seen by the Ordinance map *) occupy the greater part of the county of Glamorgan, all the other formations lying in patches round it. We have nothing newer here than the lower secondary (except alluvium, newer pliocene, or post-tertiary formations), consisting of lower lias, rhœtic-beds, keuper, dolomitic limestone, and conglomerate. The last three mentioned are triassic formations. Of the primary formations we have a good collection, comprising the coal-measures and millstone-grit, carboniferous limestone and shale (lower carboniferous), old red sandstone and cornstone (upper Devonian), Ludlow rocks, Wenlock limestone and shale (upper Silurian). We thus see that the coal-measures are by far the largest formation in this district, lying to the north and surrounded on the south by patches of lower secondary or primary formations. This coal-field is composed of lofty hills, whose average height above the level of the sea is 1000 feet, though some (as Garnfach, a mountain south of Hirwain and Twmbarlon, one mile east of Risca, and the Garths, near Walnut-Tree Bridge) rise to a much greater height. Therefore, but for means provided by the all-wise Creator, the priceless stores of treasures buried in these hills would be almost useless to man, or, at any rate, to the poorer classes, from the difficulty of carrying them to the market and their consequent dearness, were it not that a means has been found by Him who does all things well, through which the carriage of the coal is not only made practicable, but absolutely easy, not only to Wales, but to all parts of Great Britain and the world. A series of valleys intersect the hills in every direction, up which innumerable lines of railway run, so that there is not a colliery in South Wales which cannot send its coal or minerals straight from the pit's mouth to any part of the kingdom by rail. The principal valleys

* The lecturer exhibited numerous maps and diagrams in illustration of his paper.

are the Vale of Neath, the Llynir Valley, Ogmore Valley, Ely Valley, Rhondda, Rhondda Fach, Aberdare, Taff Vale, Rhymney, and Ebbw, up all of which run railways of the same names as the valleys they traverse. In addition to these, the following railways may be mentioned—the Sirhowy and Eastern and Western Valleys Railways. Cardiff, Newport, and Swansea are the three chief ports from which the coal is shipped.

The extent of the South Wales coal-field (that is, of coal-producing strata) is, from Blaenavon and Pontypool on the eastern outcrop to St Bride's Bay, Pembrokeshire, on the west, a length of about ninety miles; while the width varies greatly from the north to the south outcrop, being, in Monmouthshire and Glamorgan up to the river Loughor (the county boundary with Caermarthenshire), about sixteen miles (in this is included the small area lying in Brecknockshire); from the Loughor river to Kidwelly and Caermarthen Bay about ten miles; under the bay to Saundersfoot about five miles; and from Saundersfoot, through Pembrokeshire to St Bride's Bay, an average width of four miles.

The superficial area of the entire coal-field is about 937½ square miles, or 600,000 acres; the average thickness of the pure coal being about sixty feet (that is, placing all the different seams together horizontally and measuring them in section), while the amount of coal yet obtainable from the coal-field cannot be less than about thirty-six thousands of millions of tons.

At its eastern end the coal-field is bituminous, but from Cyfarthfa to Mynydd Mawr and Gwendraeth it is anthracite. Bands or seams of argillaceous ironstone are also found in many of the collieries, of which Skyboraven Colliery, near Aberdare, may be taken as an example. These bands of ironstone, taken in the aggregate, are about seventy inches thick in horizontal section, and make the finest foundry pig-iron, bars, and rails in the world.

The dip along the north outcrop of the South Wales coal-field is very moderate, ranging from three to six, and, in some cases, nine inches per yard, while, on the south crop, it varies from nine to twelve, fifteen, and eighteen inches per yard, the beds gradually flattening northwards, and leaving a large area in the centre of the field comparatively level, excepting where the anticlinal line disturbs the stratification. Even adjoining that, however, the dip varies very much. The most numerous 'faults' of the field run from north-west to south-east, and vary in amount of vertical displacement up to 750 and 900 feet. Others run in an east and west direction, being in some places from 1200 to 1500 feet. The largest fault in the field is in Pembrokeshire, and this is as much as 2000 feet in vertical displacement. There are two ways of getting at the coal practised in South Wales—one, the common

way of sinking pits or vertical shafts; the other, driving levels or lateral shafts in the sides of the hills. Of course, the latter mode can only be practised with success where there are high hills, and where the coal-seams lie above the level of the valley, but it is a system very generally practised in South Wales. The deepest pit or vertical shaft in the field is one sunk in the Ffochrhiw Colliery (by the Dowlais Company), which is 1305 feet deep.

The coal-field contains good fireclay, alum-shales, and horn-coal, yielding at Pontypool fifty to fifty-five gallons of crude oil per ton of shale. By removing in distillation twelve to fifteen per cent. of mineral turpentine (used generally for machinery, paint, and out-door ironwork) a good lubricating oil is left, and from it, by further refining, fine oil is produced. It also contains paraffine.

The first mention of coal being worked in this field we find to be about the year 1570, in a description by George Owen, Esq., of Henllys, Pembrokeshire. In 1697, nearly a hundred years later, the first fossil from the coal—a *Stigmaria*—was described by Dr Tancred Robinson of Usk, Monmouthshire. The steam coal was first worked in 1836 by Messrs Wayne, near Aberdare. The coal raised in this field in 1854 was 8,500,000 tons, in 1868, 13,210,000 tons; being an increase of 4,710,000 tons in fourteen years.

The pig-iron made in this district in 1827 was 272,000 tons, and, in 1868, 894,255 tons, being an increase of 622,255 tons in forty-one years. The highest ground in the coal-field is Garn-fach, south of Hirwain (1971 feet), but just beyond the northern outcrop the old red sandstone, composing the Brecknockshire Beacons, rises nearly to the height of 3000 feet.

There are two ways of working the coal after the pit has been sunk or the level driven. One is called 'post-and-stall,' the other the 'long-wall' system. The post-and-stall or board-and-pillar system is the one most largely practised: the men open ranges of working places, each as wide as the nature of the floor and roof will admit of with safety, and each divided from its neighbour by masses of coal broad enough to sustain the pressure from above. The long-wall system is directly opposite to this. In working upon this method the men remove the whole breadth of coal over a long continuous face, supporting the roof at the immediate 'face' or end of the workings by temporary props, and allowing the superincumbent strata to break down bodily at a few feet distance behind the workmen.

It will be as well to explain here some of the most familiar mining expressions. In the case of a vertical shaft, as soon as the coal is reached, the men proceed to drive a level—that is, they cut a passage, horizontal or nearly so, but sloping slightly towards

the bottom of the shaft, in order to let the loaded trams be drawn down more easily. In post-and-stall work, when they take out the coal in the stalls, they fill the vacant places with rubbish, and this is called goaf, or, as the colliers term it, 'gobb.' When a level or heading is driven through hard rock—that is, through the coal-measure sandstone—it is called 'cross-measures' (written in the Survey-book × measures). The end of the different workings is called the 'face of the workings.'

The fossils in this coal-field are very numerous and diversified. The shells in the ironstone are peculiarly abundant, especially the shell *Anthracosia*. Teeth also of fish are plentiful in the coal-measures.

To conclude, I will quote a passage from the 'Memoirs of the Geological Society of Great Britain' concerning the conditions under which the coal was deposited :—

'The sea water must have had frequent access to the coal growths, and, if the beds were not purely marine, they must at least have been estuary deposits. Throughout the whole duration of the British coal-measures there were repeated subsidences, with periods of rest (not of elevation). The lower coal-measures of Lancashire contain unmistakable bands of marine fossils—*Aviculopecten*, *Goniatites*, *Nucula*, squaloid fish, &c.—while the middle and upper coal-fields are more prolific in *Unio* bands and fish. The margin of the sea of this period was occupied by vast marine savannahs of some peat-creating plant, growing half immersed, on a perfectly horizontal plain, and this fringed and interspersed with forests of trees, shedding their leaves upon the marsh. The ancient shore was covered with vast swampy forests of water-loving plants, protected from the tidal action by sandbars, and therefore in the condition of great maritime lagoons. In such putrid seas accumulations of black shale and fœtid limestone would be a normal state of things ; the carbonic-acid generated by decomposition of the plants would readily unite as a bicarbonate with whatever iron was present in the water, and be precipitated as a carbonate of iron in the form of ironstone. There would be sea inhabitants different from those found within tide-marks on ordinary shores. Races of mollusca fitted for burrowing and living in such localities, with annelids to devour the decaying vegetable matter, would be abundant, and perhaps would be the only tenants of the bottom. The epiphytal ferns which grew on the decaying trees, and such water or land insects as could find a home in the hollow stumps, together with a few aquatic, and possibly even terrestrial, lizards, would all find an appropriate residence in the swamp, and contribute their spoils to the future coal-bed.'

In concluding, I must beg to apologise for the hasty manner in

which this paper has been prepared, but I have only found an hour or two of spare time in which to write it, though it is (excepting only the last paragraph) a collection of notes made by myself, or given me by my kind friend Mr William Adams, President of the Cardiff Naturalists' Society.

A vote of thanks to Mr Cruttwell for his able paper, and the hearty interest shown by him in the Society's welfare, was proposed by J. F. M. H. Stone, and carried by acclamation. In reply, Mr Cruttwell spoke of the great benefits his connection with the Society had conferred on him when he was at school, and said that he could never forget the pleasant hours he had spent at the meetings.

In reference to a subject which had sprung up at the discussion on P. R. Ogle's paper (June 9th), H. R. F. Brown stated that the highest balloon ascent yet made was that of Gay-Lussac in 1804. He ascended to the height of 23,000 feet; but Briocchi, in 1806, when endeavouring to ascend to a greater height, failed through the bursting of his balloon.

MEETING, July 7, 1871.

The President in the Chair.

The sixth meeting for the term was held on 7th July. Fifty-eight members and visitors were present.

R. B. Don read the following paper on

A CURIOUS OLD CHURCH.

I am afraid that what I am going to speak about will seem too insignificant to be brought before the notice of so large a Society; that when I have finished, you will exclaim, 'What we have heard is all very well in its way, but hardly worth telling before so many listeners.' For I cannot speak to you of St Mary Redcliffe, I cannot describe some grand old pile which has been the wonder of ages, or some ruin whose name is a household word. My subject is a little country church—more resembling a superannuated barn than anything else—which probably none of you have ever heard of, and which it is quite likely no one present will ever see. But this fact has seemed to me a recommendation rather than an objection, for I cannot help thinking that a Society such as ours requires, not so much long and elaborate compilations from

encyclopædias and dictionaries, as short notices from members of things which they themselves have come across, and of which the rest might otherwise have never heard.

If any of you ever happen to be in Berwickshire, and near the parish of Polwarth, you ought to go and see the church there. It is a small building of the plainest sort, being, as I said before, like a barn; but its antiquity is great, and there are interesting historical associations connected with it. On a stone over the door there is a roughly-carved inscription* which tells, in rather doubtful Latin, the various times at which it was built. I shall not trouble you with the original, but may briefly say, that it shows how the church was first founded before the year 900 A.D., by the lords of the estate; how it was repaired in 1378; and again (finally) in 1703, since which date it has remained untouched. At one extremity there is a small tower, and in the wall at the other end a grating is noticed reaching about a foot above the ground. If you stoop down and look through this, you will see, when the eyes have become accustomed to the gloom, a subterranean vault with nothing in it but three or four mouldering coffins. But with this vault a story is connected—one of the many tales of strange escapes made in times of political persecution.

After the discovery of the Rye House Plot, in 1681, a diligent search was made, not only for those who had taken a part in it, but also for many who were guilty in a less degree, inasmuch as they wished to exclude the Duke of York from the succession. Among the number of this latter class was Sir Patrick Hume, of Polwarth, who at a subsequent time became Earl of Marchmont. The way in which he is said to have received warning of his danger is curious, for the story runs that a party of soldiers having come to the house of a lady, who, though friendly to the government, was also well inclined to him, her suspicions were aroused by the questions they asked regarding the road to Polwarth Castle. She did not dare to despatch a letter or verbal message to Sir Patrick; she therefore sent a boy to him with a sheet of paper, enclosing nothing but a feather, and on various pretexts detained the

* The inscription runs thus:—Templum hoc Dei cultui in ecclesia de Polwarth, a fundi dominis ejusdem prius designationis, dein cognominis, ædificatum et dicatum ante annum salutis 900, rectorioque beneficio dotatum. Sed temporis cursu labefactum, a Dno. JOHANNE de[1] SANCTO CLARO de Herdmanston genere Dni. Patricii de Polwarth de eodem, circa annum 1378, reparatum, tandem vero vetustate ad ruinam vergens, sumptibus utriusque prosapiæ hæredis, Dni. PATRICII HUME, Comitis de MARCHMONT, &c., summi Scotae Chancellarii, et Dnæ GRISSELLAE KAR, Comitissæ, ejus sponsæ, sepulchri sacello arcuato recens constructum, et campanarum obelissco adauctum fuit. Anno Domini 1703.

[1] *i.e.* Lord John Sinclair.

soldiers as long as possible. Danger sharpened Sir Patrick's wits, and he understood the hint to *fly*. The only safe hiding-place he could think of was the family vault under Polwarth Church, and there he remained secure for some weeks, spending the days underground, and sleeping at night in a little room in the tower. At midnight, food was brought him by his daughter Grizell, who, though possessed of all the superstitious fears common in that age, braved even the ghosts of the churchyard to assist her father. The dogs at the manse, which stands near the church, seemed likely to betray her by their barking, and the minister was therefore persuaded to put them out of the way by an alarm about mad dogs. The servants could not be let into the secret, and Grizell was accustomed to abstract food at the family dinner in order to get it without their knowledge. One day there was a sheep's head put upon the table, and she, with her usual dexterity, managed to get it all into her lap, and safely concealed. But suddenly her youngest brother, astonished at her appetite, shouted out, 'Mamma, look at Grizzy, while we were supping the broth she has eaten up all the sheep's head!'

One day Sir Patrick Hume saw a skull move, a mouse having got into it. This he considered as a sign to leave the vault, though why, I know not. He may have supposed that the spirit of his ancestor was uneasy because of some impending danger, but I am more inclined to think that he was getting heartily tired of his confinement, and glad of any pretext to get out of it. At all events he left the vault and escaped safely to Holland, while the very next day a party of soldiers came to Marchmont to search the country for him. Sir Patrick Hume was afterwards concerned in Argyll's rebellion, and eventually came across with the Prince of Orange.

When the vault outside has been seen, it is quite worth while to get into the church itself. Everything there is so old and so plain, that the very simplicity of it constitutes its charm. The ivy, with which the outside is covered, has found its way between the top of the walls and the beginning of the tiles, and until a year ago clothed in one mass of green all the roof of the interior. It was during the last summer holidays that I saw Polwarth, and I am sorry to say that just before that time the ivy growing inside had been removed, as fears were entertained of its completely destroying the woodwork. But perhaps nothing can give you so good an idea of the primitive simplicity of this little parish church as the fact that, about thirty years ago, rabbits, which are still plentiful in the graveyard, used to make entrances to their holes in the hard ground which constitutes the only floor. The shepherds were in the habit of bringing their dogs to church with them, and

they, being well trained, generally behaved themselves. But when, as frequently happened, a rabbit, in the middle of the service, popped out of one of the holes, and began hopping about the church, it was too great a temptation for the poor dogs to withstand, and a regular hunt began. The minister being naturally scandalised by the occurrence of such scenes of confusion, got the holes filled up at last, and the rabbits banished. Nothing could give a more characteristic picture than this.

I have no more to tell, but should any of you now feel an interest in this curious old church, and resolve to go and see it, if you are ever in that part of the country, my object is gained. It is well worth your while to do so, for there is a quaintness and genuine savour of antiquity about it, which, to me at least, gave far more pleasure than has the sight of many a church of infinitely greater pretensions.

W. J. P. Wood next read a paper on 'The Organ.'

The President here announced that the Society's annual picnic having been sanctioned by the Head-Master, would take place on Saturday, 15th July, and he proposed that a vote of thanks be given to the Head Master for his kindness. This proposal was seconded by T. H. Warren, and carried unanimously.

W. Oliphant then read the following paper on

COFFEE.

Coffea is a genus of *Cinchonaceæ* or *Rubiaceæ*, comprising fifty or sixty different species, the most interesting of which is the *Coffea Arabica*, or Coffee-tree proper, from which we obtain the berries used for making the beverage coffee.

To the order of Cinchonaceæ belong some very valuable trees, which grow chiefly in the valleys of the Andes. These trees are evergreens, and owe their value to the medicinal properties of their barks. The best known barks are the Peruvian and that from which quinine is extracted. The cinchona trees grow in clumps in the dense forests of Peru, and are very often surrounded by such a luxuriant growth of underwood and trees of various kinds that they are with difficulty approached by the bark collectors, who often spend long periods in the forests looking for them. The word cinchona is said to have arisen from the name of the wife of a viceroy of Peru, who brought the drug from South America in 1639. The coffee shrub (*Coffea Arabica*) is a native of the mountainous regions in the south of Abyssinia, where it grows wild in great profusion. The tree grows to the height of about twenty feet in its wild state, but, for convenience in gather-

ing the berries, it is rarely allowed to grow higher than from ten to twelve feet. Its stem is about four inches thick, and has a whitish and somewhat rough bark. The leaves are about six inches long, by two and a-half wide, and are of an oblong and somewhat oval shape, dark green above, but lighter coloured underneath, and they terminate in a long narrow point. They are arranged almost opposite one another on the branches, and rather close together.

The flowers, produced in clusters at the base of the leaves, are of a white colour and very fragrant. They last, however, only for a short time. The corolla is cut into five divisions, bearing the stamens fixed round the top of the tube and protruded beyond it. To flowers succeed little red fleshy berries, very much like cherries, which are, according to some, good to eat. Within them are the coffee seeds, covered with a thin parchment-like skin. As the berries grow ripe they get darker in colour, and finally, instead of the fleshy berry there is left a dark brownish-red pod. The seeds are convex on the outside but flat on the inside, which is marked by a longitudinal furrow.

The early history of coffee is rather obscure, but it is pretty well agreed that the natives of Abyssinia first made use of it, and that it was drunk in Persia as early as the year 875. From Abyssinia the Arabs took it to Arabia, where in a short time it superseded the native beverage made from the leaves of the Kât (*Catha edulis*). This happened early in the fifteenth century, when a learned Scheick, named Djemal-eddin-Ebn-Abou-Alfagger, on his return from Abyssinia, brought some bags of coffee to Aden. The new importation met with violent opposition from the priests, who said that it was one of the intoxicating drinks forbidden in the Koran, and therefore forbade its use; but on some learned physicians declaring that it was harmless, the prohibition was removed.

The plant was at first chiefly cultivated in Yemen (or Arabia Felix, as that district was then called), and for nearly two centuries Arabia supplied all the coffee used. Near the end of the seventeenth century the Dutch took several plants to Java. From thence they sent one to the Botanical Garden at Amsterdam, and it is said that all the coffee plants in the western world have sprung from this self-same individual. Coffee seeds were first introduced into Europe about the middle of the sixteenth century, at Constantinople, but the first coffee-house in London was not established till 1652, by a Greek named Pasqua. Twenty years afterwards (1672) a similar establishment was opened at Marseilles. Early in the eighteenth century the growth of coffee was introduced into the West Indies.

The tree does not thrive well in rich ground; it likes a western exposure and loose gravelly soil, where it may often get showers of rain. When the berries are ripe they are pulled from the trees and transferred to a machine called the 'pulper,' by which the outer pulp is removed. The seeds are then soaked in water to remove all mucilaginous matter, and, after they have been carefully dried, the parchment-like skin in which they are wrapped is removed by a winnowing machine. In Brazil, however, the berries are gathered from the trees, and allowed to dry without the fleshy part being removed. They are, when dry, put into a mill which crushes the husks, and allows the seeds to be separated. By this method the coffee is said to have a finer flavour.

Before being used for making our well-known beverage, the coffee seeds undergo the process called 'roasting.' Here the coffee loses in weight, though it gains in bulk, and it assumes a colour more or less dark, according to the amount and duration of the heat applied.

The raw coffee-bean contains nearly :—

34	parts per cent.	cellulose.
15	,,	sugar.
13	,,	fat.
12	,,	water.
10	,,	casein.
3	,,	nitrogenous substances.
3	,,	oil.
6	,,	ash.
3	,,	other matter.
8	,,	caffeine (theine).

The last-named substance is found in tea also, and it separates from its solutions in silky needle-shaped crystals, which have a slightly bitter taste, melt at 178° C. (352° Fahr.), and sublime without decomposition at a higher temperature. Their composition is $C_8H_{10}N_4O_2 + H_2O$. This caffeine, or theine, is a weak base which forms salts with acids. It exists in different proportions in different kinds of coffees. The coffee most generally consumed in this country contains from a quarter of a pound to a pound in the hundred. By boiling a mixture of coffee and slaked lime in the proportions of two of coffee to one of lime, half a per cent. of theine may be extracted. Taking equal weights of tea and coffee, tea yields about twice as much theine as coffee does, but as we generally use a much greater weight of coffee than of tea, a cup of coffee will contain as much theine as a cup of tea; while in France, where the tea is usually weak and the coffee strong, a cup of coffee will contain nearly twice as much caffeine as a cup of tea does.

The methods of preparing the beverage differ in different countries. At Constantinople the coffee is roasted almost black and then ground extremely fine, so that it is something like charcoal powder. In Arabia, when guests are invited to a person's house, the slave who usually makes coffee lights a fire of charcoal in a small stone furnace, and puts a large coffee-pot, full of water, by the side of it to get warm, while he proceeds with the rest of his operations. Then, from a niche in the wall, he takes a dirty rag containing coffee-seeds. From this he takes two or three handfuls and puts them into an iron ladle. Then he blows the fire bright, and puts the ladle on it; when the beans begin to crackle and smoke, but before they are in any way burnt, he takes them off and pours them out on a little grass platter to cool, and at once puts the large pot on the fire to boil. While the water is boiling he draws towards him a deep stone mortar, with a narrow pit at the bottom of it, and, pouring the berries into it, proceeds to pound them with a stone pestle about a foot long by an inch and a half wide. When they are crushed, but not reduced to powder, he scoops them out, and filling a smaller coffee-pot with boiling water from the larger one, he puts it on the fire, shaking the pounded coffee into it, and occasionally stirring it with a small stick to prevent too rapid ebullition and overflowing. Out of another rag he then takes a little saffron and a few aromatic seeds (without which the coffee is not considered perfect), and these, after being slightly pounded, are thrown in among the simmering coffee. Of sugar there is none, nor does milk appear either. Lastly, the slave strains off the liquor through some filters of the inner bark of the palm-tree (placed for the purpose in the spout), and he pours out the coffee into diminutive cups, first, however, himself taking some of the coffee, in the presence of the master and guests, to assure them that there is no 'death in the pot.'

Coffee acts on the brain as a stimulant, producing sleeplessness, and it is in consequence valuable as an antidote to narcotic poisons. This property it owes (1) to a volatile oil (produced in roasting), whence also comes its fragrant smell; and (2) to the crystalline caffeine. This caffeine, to which we have already alluded, is found in some few other plants, and it is also contained in the leaves of the coffee-tree itself. Indeed, the natives of Sumatra use these leaves for infusion in preference to the berries. It was even proposed to introduce this coffee-tree tea into England, but the attempt failed, principally owing to the fact that the coffee-tree, unlike the tea plant, cannot endure the frequent deprivation of its leaves, but speedily dies.

Besides the fruit of the true coffee-tree, numerous other plants have been used or proposed as substitutes for Arabian coffee. To

succeed they must contain an aromatic principle, a bitter, and an astringent principle. These properties are found to exist more or less in the following :—

The roasted seeds of the yellow-water iris (*Iris pseudacorus*) ; the seeds of a plant called in Turkey 'Kenguel ;' the roasted acorn (often used in the south of France, and imported into England, probably to adulterate coffee) ; many other plants, such as beans, wheat, nuts, the seeds of the common broom, &c.

That, however, which is most extensively used of all to take the place of coffee is the root of the plant named chicory.

Chicory, succory, or wild endive, is one of our native weeds, and may often be seen, with its pale blue flowers, in the meadows. It has a white tap-root, not unlike that of the parsnip, which, when cultivated, increases considerably in size. It contains, in large quantity, a bitter juice, which led to its adoption as a substitute for coffee. To prepare it for use this method is adopted :—The root (taken up before the plant shoots into flower) is washed, sliced, and dried, and then roasted till it is of a dark brownish-red colour, when it is ready for grinding. It does not in any degree possess the fragrant smell of coffee, though to some the bitter taste caused by its addition is an improvement to the coffee.

The simplest way of detecting a mixture of coffee and chicory is to put the powder into some clear *cold* water, when the chicory will give a coloured infusion, while, if pure coffee alone is present, the water remains unaltered. Again, some of the powder may be gently heated with sulphuric acid and peroxide of manganese, when golden-yellow crystals of a substance called *kinon* will sublime. A suspected mixture of chicory and coffee may also be detected by testing with salts of peroxide of iron. The infusion of chicory is brownish-yellow in hue, and only becomes a little darker when such a salt of iron is added, giving no precipitate. The infusion of coffee, on the other hand, is of a rich brown colour, and it becomes green when the iron solution is added, giving a brownish-green precipitate. Owing to the demand for chicory to mix with coffee, it is as often adulterated as coffee itself. The common ground chicory of Berlin is said to contain half its weight of wasted turnips, and on the Rhine carrots are used for the same purpose. Again, roast wheat, beans, potatoes, ground acorns, &c., are often added to the 'coffee' (to make it palatable ?), while, to please the eye, Venetian red, brick dust, and mahogany sawdust, lend their services in the cause of adulteration !

A lively discussion on some points mentioned in the paper

afterwards took place, in which the President, Messrs. Grenfell, H. Wills, H. Proctor, and Ogle, took part.

The Society then proceeded to settle the place at which the picnic should be held. The choice evidently lay between Brockley Combe and Cheddar, and it was decided by a large majority to go to Brockley Combe—the scene of last year's unfortunate *wet* excursion. The following stewards, in addition to the members of the regular Committee, were elected to make arrangements for the picnic :—R. B. Don, W. E. Evill, J. B. Heath, W. Claxton, C. T. Blanshard, D. H. Walsh, and J. P. Bush.*

It was announced that the Museum was now open on four days of the week for the use of Members, and on two days for other collegians.

MEETING, July 14.

The President in the Chair.

The seventh meeting for the term was held on 14th July. Sixty-eight members and visitors were present.

The following donations to the Museum were acknowledged :—Indian and other coins, by A. Paul, Esq., O.C. ; fossils, by A. Cruttwell, Esq., O.C., Cor. Mem.

On the proposal of the President, J. I. Fox, Esq., O.C., Trinity College, Dublin, was elected a Corresponding Member of the Society.

D. Pearce then read a paper on

THE BIRDS OF CLIFTON.

In my paper this evening on such a very extensive subject, it is my intention only to dwell briefly on a few of the most important and interesting birds seen in this neighbourhood. When I say birds of Clifton, I do not mean those *peculiar* to it, as there are very few, if any.

Clifton is the favourite resort of many of our sweetest songsters, and I think there are few places where one can see so great

* The picnic accordingly took place on 15th July, and the members proceeded in open carriages and breaks to Brockley Combe about noon. The day was fine, and the excursion was therefore made under favourable auspices. Nearly every ordinary member of the Society attended, together with the President and Mr. Grenfell. The Rev. J. Greene was unavoidably absent.

a variety of the feathered tribe. This is easily accounted for when we consider the varied scenery of the district, suited almost to every species of bird.

I will first proceed to speak of a few of our summer visitants, commencing with the nightingale. It is about the end of April when we first hear the sweet notes of this bird. This year I first heard it on the 29th of April, but the time depends to a great extent on the clemency of the weather. The nightingale does not sing in the evening alone, as is very generally supposed, for in the brightest hours of the morning you can often hear its melodious song. About Clifton it is not very frequently met with, and, I believe, it used to be more plentiful than at present. Nevertheless, I have often heard it in the Leigh woods.

The nest is generally placed on the ground, in some natural hollow, and it is composed of dry leaves, fibrous roots, and other similar materials. The eggs are of a regular oval form, uniformly dull olive-brown in colour.

As regards the song of the nightingale, it has been very generally described (by poets almost always) as a melancholy one, even from the time of Homer downwards. For myself, I think the song has the greatest variety and compass of any of the minstrels of the wood; but at the same time, when listening to it, you sometimes cannot help admitting with the poet that—

> 'Ne'er on earth was sound of mirth
> So like to melancholy.'

The blackcap, garden-warbler, whitethroat, and willow-warbler, are all found more or less frequently about this locality, and are amongst the most elegant and pleasing of our British birds. The song of the first named is second only to that of the nightingale in quality, and is even preferred by some people. The blackcap arrives in England a little before the nightingale. The garden warbler is more rare, and seldom seen in Clifton or its neighbourhood. The whitethroat is a very elegantly shaped little bird, commonly seen in hedgerows and thickets. It has a pleasing song, and sometimes it may be seen singing in the air while hovering over some object in a curious flickering manner, occasionally poising itself over a bush from which it has arisen. I first saw the whitethroat this year on the 23d of April. The willow-warbler is much more commonly met with, and is, indeed, one of the most numerous of our summer migrants. It is common here in the Leigh woods, generally selecting thickly-wooded uncultivated districts. This bird is very abundant in Kent.

I will now leave the warblers, and pass on to speak of some others of our migratory birds.

The wheatear is common in certain localities, and Morris mentions Durdham Down as a favourite resort for it. It is also plentiful in the counties of Lincoln, Sussex, and Cambridge, generally preferring open and exposed situations. It arrives here about the end of March, departing again in August. The birds are most frequently seen in pairs, and are somewhat shy and hard to approach. They seldom alight on a tree, and the nest is generally placed in a crevice amongst rocks, or on an old wall.

The redstart, another of our yearly summer visitants, is not a common bird, generally frequenting orchards and gardens, and is very seldom seen in waste places. I have seen several in the Leigh woods, and, I believe, it is pretty plentiful there; but as it is a bird of retired and wary habits, it usually escapes observation. The cuckoo, one of the best known of all birds, is plentiful here, as indeed almost everywhere. It arrives in England in April, and is truly the herald of the spring. It departs again at the end of July, or beginning of August. The habits of this bird are familiar to everybody, and therefore I need not say much about them here. The birds are plentiful on the Somerset side of the bridge, especially at some distance past the village of Leigh. The nest generally selected by the cuckoo to build in is either that of the hedge-sparrow or water-wagtail, and many are the anecdotes told about the battles between the rightful owner and the usurper, the victory almost always ending in favour of the latter. The note of the cuckoo ceases about the end of June as a rule, but it has several times been heard as late as the 15th or 16th of July. An unusual quantity of cuckoos have appeared in England this year, and I have seen this fact remarked more especially in some localities.

I will now proceed to mention the swallow family. There are four species: common swallow, martin, sand-martin, and swift. They resemble each other in a great many points, and are, no doubt, very familiar to most people. The swift is the rarest, and arrives latest in England. It is, I believe, less frequent than it used to be; but why this should be so, is entirely unknown. The favourite haunts of the swift are buildings in towns and villages, church steeples, fortresses, and castles.

I have seen it remarked several times that the swallow is not so plentiful in England this year as usual, and around London it certainly has been comparatively scarce.

All these birds are more or less common in Clifton. The sand-martin I have not seen on this side of the river, but at some distance across the suspension bridge it is common enough. The nest is remarkable, being placed at the bottom of a tunnel bored

in the sand, generally about two feet in length, though I have frequently found nests of much greater length.

Another of our elegant summer visitors is the flycatcher. Of it there are two varieties, the pied flycatcher, and spotted or common flycatcher—the former being excessively rare and seldom seen, although this year I have heard more instances of its occurrence than I ever remember to have heard before. The common flycatcher, however, is frequently seen here, especially on this side of the river. It is very amusing to watch it when in pursuit of insects. It then seems almost to be lifeless, perched on a rail or the top of a stake, but all of a sudden it darts off in a zig-zag course after some winged insect, and soon returns again to the same spot, having effected its capture. The nest is placed in various places, a tree or hole in a wall being the favourite positions, and very little care is taken to conceal it.

I will now pass on to the finch tribe,—viz., goldfinch, yellow-hammer, greenfinch, chaffinch, and bullfinch. All these birds are more or less common in Clifton—the goldfinch is much less frequently seen here than elsewhere. This bird is one of the prettiest of our English birds, and is a deserved favourite, having not only a gay exterior, but also docility of habit and a beautiful song. I have only once seen it on the Clifton side of the river. Its favourite resorts are tracts of uncultivated land, on which it generally finds a quantity of wild seed-bearing plants, of which the thistle is its especial favourite.

The chaffinch and greenfinch are familiar to everybody, and therefore need little description. A curious fact respecting the former of these birds is the partial emigration which takes place in winter, and the separation of the males and females. Its nest also is the most wonderful of any of our British birds', and hardly surpassed in curious structure by any other. It is placed on a tree or thick shrub (very often on the apple), and is constructed by the female bird alone. I read the other day of a very curious place selected for the nest, namely, *the skeleton of a jackdaw* suspended on a tree with the wings outstretched. It was found in a garden in Kent. The nest is so well adapted to the colour of the surrounding objects that it almost defies detection.

The bullfinch is by no means a common bird in Clifton, but I have been informed that it is frequently met with at some distance over the river. It is a bird of retired habits, and hardly ever seen in barren districts.

The titmouse family is a most interesting one, and five species out of six found in England are very common here—namely, great-tit, blue-tit, cole-tit, marsh-tit, long-tailed-tit. All these are of

very small size, the largest not exceeding the dimensions of the house-sparrow. They are very lively little birds, constantly in motion, hopping from branch to branch in search of insects, which form their principal food.

About here they are all to be seen in the Leigh woods, especially the great-tit and blue-tit. The cole-tit and marsh-tit are less common. The long-tailed-tit I have frequently seen along the banks of the Trym.

The nests of these little birds are placed in walls or trees. They lay numerous eggs of a white colour, dotted with red or brown. They are generally seen moving about in troops, and sometimes associating with other birds of the same genus; none of them are gifted with much power of song, and they seldom do more than keep up a continued chirping while searching for insects.

I will now say a word or two about the larks. There are several species of larks, but only one, I think, occurs in Clifton,—namely, the skylark. The woodlark is met with pretty frequently throughout England, but I have never seen it here.

The skylark is to be found in all situations from north to south. During the winter months it migrates south, and can then be seen in large flocks in the ploughed and stubble fields. Every one knows the song of the skylark. I will only say that it is to be heard throughout the greater part of the year, commencing about the middle of February. The first time I heard the full song this year was on the 23d of that month, in a field near Penpole Point. I believe it has been heard as early as the middle of January.

The pipits or titlarks are similar to the larks, both in appearance and habit. The most common is the meadow-pipit, which is peculiar to commons, mountains, rocky sea-shores, and other wild wastes. Occasionally they may be seen in streets of towns, driven thither by stress of weather. They are often found about this neighbourhood in suitable situations. This is one of the many different kinds of birds which feign being wounded, in order to entice away intruders from their young.

The tree-pipit is a migratory species, and in this respect differs from the meadow-pipit. It appears in England about the 20th of April, and departs again in September.

The rock-pipit I have never seen in Clifton myself, but as it is a very widely distributed bird, it is no doubt to be found in rocky and barren places about the locality.

Everybody is acquainted with that graceful little bird the water-wagtail. It occurs almost everywhere, but its favourite haunts, as the name signifies, are the margins of rivers and lakes.

There are five species of wagtail,—the only other one seen here is the yellow wagtail. It frequents downs and open arable lands, and is similar in its habits to the grey species. The nest is built on the ground, and the bird is a migratory one, arriving here in March.

The shrikes are very interesting birds in many respects. There are two species,—the great grey shrike, and red-backed shrike. The latter only is to be found in this neighbourhood, and is the commonest of the two species. There is a hedge not far from the Stoke woods in which this bird builds, and I believe it is the only place where the bird can be found in or near here. The food of the red-backed shrike consists of small birds and mice, but I have heard that they will sometimes pursue even blackbirds. They are frequently taken in the nets of fowlers when in the act of striking at their decoy birds.

Another remarkable bird, which perhaps I ought to mention, is the nightjar or goatsucker. It has frequently been heard in the Leigh woods, and was seen a few evenings ago by the President of this Society, on Durdham Down. It is a migratory bird, visiting this country about the middle or end of May, and leaving again at the end of September. One remarkable trait in its character is, that it perches *lengthwise*, instead of *crosswise*, on the branch of a tree. It is a bird of nocturnal habits, and its power of flight surpasses that of the swallow.

The woodpeckers are not so common in the neighbourhood of Clifton as one might expect, but they can often be seen and heard in Leigh woods. Some time ago a specimen of the green woodpecker was shot there by A. D. Greene, and it is now stuffed in the museum. This bird is the handsomest of all the woodpeckers, and at the same time one of the commonest. Morris also mentions Gloucestershire as one of the few places where the lesser spotted woodpecker occurs, but I have never seen it myself.

The nuthatch and tree-creeper are closely related, in many respects, to the woodpeckers. They both commonly occur in this neighbourhood, particularly the tree-creeper. The nuthatch feeds on berries, acorns, nuts, seeds, and insects. The nest is placed in some hole in a tree, and, if the entrance is too large, the bird narrows it with clay until it is of the proper dimensions.

The tree-creeper 'remains with us throughout the year, though in other countries it moves from more exposed to more sheltered localities, for the purpose of rearing its young, arriving thereat in March, and departing again in September or October.' It is very similar in its habits to the nuthatch.

I will now say a word or two about the thrush family. These are excessively interesting birds, the most important being the

song-thrush, blackbird, missel-thrush, redwing, and fieldfare. All these are more or less common here. The first two, at least, must be very familiar to every one. The fieldfare is a migratory bird, arriving in this country about the beginning of October, and thus avoiding the winters of the north. It comes in large flocks, and again leaves us about the end of February. The fieldfare is common in Clifton during the winter months, and I have frequently seen great numbers on King's Weston Down. In very severe winters they frequent gardens and cultivated districts, hawthorn and other berries supplying them with food when such is the case. They are nearly always seen in large flocks, sometimes of as many as several hundreds. Occasionally, however, two or three withdraw themselves from the rest, and frequent the same localities as the thrush and blackbird. Last February I saw a single fieldfare on King's Weston Down, and that is the only instance I remember. Mr Knapp, speaking of the fieldfare, says, 'In this country (Gloucestershire) the extensive lowlands of the river Severn are, in open weather, visited by prodigious flocks of these birds; but they leave these marshy shores as soon as the snow falls or hard weather comes on, most likely retreating to a more genial neighbourhood until the weather breaks up again. They may then be seen returning to their worm and insect food in the meadows.'

The missel-thrush is, in many of its habits, similar to the fieldfare. It is a permanent resident with us, and pretty generally distributed. Like the fieldfare, these birds are frequently seen in flocks of from fifty to seventy. They are constantly found in the Clifton district, especially at King's Weston Down and Penpole. In March the flocks disperse, and individuals unite themselves into pairs, frequenting some wood or orchard. The chief foods of this bird are the berries of the mountain-ash, juniper, holly, ivy, and many other trees. The nest is often placed in the hollow caused by the growth of two branches from the trunk; the eggs are from four to five in number, and are of a greenish or reddish-white colour.

I will now pass on to the rook family. The most important here are the rook, crow, jackdaw, magpie, and starling. The habits of these birds are amongst the most interesting to study. Rooks are truly gregarious, for they build together in trees, always going in company, too, when in search of food. The most important rookeries I know about here are two or three at Long Ashton, one near Leigh Court, and on the Clifton side of the Avon there is one in the grounds of an old mansion on the road to Stoke, and several others of smaller size. The food of this bird consists of the larvæ of cockchafers, beetles, and moths. Early in March the

nests of the previous year are begun to be repaired, and new ones are of course added. As every one knows, the rook very generally builds its nest in the vicinity of old mansions, chiefly because near such places the timber is mostly old and well-grown. The carrion-crow is, I believe, very uncommon about Clifton, but I have not been able to gather any accurate information concerning it. It is very much like the raven, and feeds on all kinds of animal food, alive or dead. It is a most predacious bird, and a great destroyer of young lambs and game. The nest is built on rocks or trees, generally in very lofty situations. It is made of sticks firmly cemented together with mud. Crows are said to pair for life.

The jackdaw is very commonly seen in Clifton—even more frequently than the rook—chiefly, I suppose, because of the good nesting places it finds in the rocks by the river. There is a very large colony of jackdaws at St Vincent's Rocks. Sometimes you may find their nests in trees, but this is not often the case. The eggs vary from four to six in number, and are of a pale blue colour.

Magpies are common across the river in Leigh woods. They are generally disliked by gamekeepers and farmers on account of their poaching propensities. The magpie's appetite, like the jackdaw's, is not a very selective one—young lambs, rabbits, game, fish, carrion, and grain, all meeting its requirements.

Amongst the larger birds, and birds of prey, seen in Clifton and its neighbourhood, I ought to mention the sparrowhawk, kestrel, and owl, all of which may often be observed in Leigh woods and the surrounding country. Sea-gulls are frequently seen in company with jackdaws on the banks of the Avon. The heron, also, is very common in the low fields surrounding the mouth of the river, and also about Penpole Point.

The only instance on record of the Egyptian vulture occurring in England, happened on the shore of the Bristol Channel in the year 1825; one of them was on the wing at the time, and it was seen in the neighbourhood for a few days afterwards; another was feeding on a dead sheep, and, being either too hungry or too sated to be disposed to leave it, was approached sufficiently near to be shot.

A discussion on this paper subsequently took place, in which the Rev. J. Greene, Messrs. Barrington-Ward, Don, Kent, and Brown took part.

F. L. Penney afterwards read a paper on 'The Bed of the Avon,' and he exhibited numerous fossils and diagrams in illustration. On this paper J. Stone spoke.

H. Proctor, Esq., O.C., was announced to deliver a lecture this evening, but as he was unavoidably prevented from attending, it was postponed till next meeting.

MEETING, July 21st.

The President in the Chair.

The eighth and last meeting for the term was held on 21st July. Fifty members and visitors were present.

The following donations to the museum were acknowledged :— Nests and eggs of the Humming-Bird (from Barbadoes), by R. Haynes ; several specimens of Lepidoptera, by the Rev. H. Aubrey.

H. Proctor, Esq., O.C., then gave an interesting and lucid account of a visit to the celebrated Tin Mine of Botallack (near St Just, Cornwall).

On the motion of the President, Mr Proctor was unanimously elected a corresponding member.

J. Swinburne (Jun. Sch. Mem.), afterwards read a paper on 'The Wild Cat.' Messrs Greene and Barrington-Ward commented on this paper, and complimented the youthful author on the care and ability he had shown in its preparation. We give the following extract :—

'The Egyptian cat is supposed to have been the originator of the domestic cat, for long ago, when Egypt was at the head of the civilised world, the Egyptains used to tame the "*Felis maniculata*," and keep it in their houses ; and a little later on, the domestic cat was so rare in England that a royal edict was issued for its preservation, in consequence of which, in 950 A.D., England was nearly over-run with wild cats, so that they came to be looked upon as obnoxious animals. The Egyptian cat was imported to Greece and Rome, and thence to England. The wild cat has thick fur, the ground colour being yellowish-grey, with dark streaks drawn over it, like a tiger's, nearly at right angles to the line of the body and limbs. Down the spine there is an exceedingly dark chain of spots. The tail is thick and short, and bushy, with black rings round it, terminating in a tip of the same colour.'

This being the final meeting for the term, the Society now proceeded to private business. Votes of thanks were first passed to

the President and the retiring office-bearers of the Society for their attention to its interests. The Treasurer having read the financial statement (which showed a considerable balance on hand) the election of officers was subsequently proceeded with.

From six candidates for the Treasurership, R. F. BRUNSKILL was elected by a large majority.

Ten names were proposed for the four vacant seats on the Committee, and of them the following obtained the greatest number of votes :—Rev. J. GREENE, J. F. M. H. STONE, R. B. DON, and D. PEARCE. T. H. WARREN (Head of the School), having also polled a large number of votes, it was proposed by R. B. Don, and seconded by C. C. Stevenson, that he should be added to the Committee as a fifth member.*

It was proposed by T. H. Warren, and unanimously agreed, that the Directors of all the Sections should be elected at the beginning of every term by the entire Society.

This concluded the business of the meeting, and the Society accordingly adjourned until next term.

PRIZE MEDAL COMPETITION.

As has been already mentioned, a donation of one guinea was lately given to the Society by Alfred Cruttwell, Esq., O.C., Cor. Mem., for the 'furtherance of the interests of the Society in whatever way the Committee should think proper.' It was determined by the Committee, with the unanimous approval of the Society, that this kind gift should be devoted to the purchase of a silver medal, to be presented to the member who should make the most meritorious collection of specimens, in any branch of Natural History, during the term.

WILLIAM SANDERS, ESQ., F.R.S., F.G.S., having consented to act as judge, the collections which had been entered were placed in his hands a few days before the end of summer term. Mr Sanders, finding that three of the competitors very nearly approached each other in merit, strongly recommended that prizes should be given to each of them, on the ground of absolute

* At a Committee meeting held subsequently, J. F. M. H. Stone was re-appointed Secretary of the Society. It was also resolved that the permanent numbers of Committee should in future be five instead of four.

excellence alone. The Committee thereupon decided to follow his advice, and the following award was made :—

J. F. M. H. Stone.....SILVER MEDAL, for a fine collection of insects, collected, arranged, and mostly named by himself.

W. B. Ffooks*.....SILVER MEDAL, for a large series of the plants of Clifton, gathered, dried, and remarkably well arranged, by himself.

M. J. Ward..... .....BRONZE MEDAL, for a series of dried plants, smaller than that of Ffooks, but meritorious, and commended as being the work of a young boy.

Three essays were sent in to compete for the Prize Medal which was offered by the President and Rev. J. Greene to the Chemical and Physical Sections for the best essay on the Spectrum. J. Norman Lockyer, Esq., F.R.S., editor of *Nature*, kindly undertook the task of adjudicating this prize. As in the case of the Cruttwell Medal, the competition proved remarkably good, and all three of the essays were reported to be 'very creditable productions.' Mr Lockyer found some difficulty in deciding between the claims of two of the competitors, and he consequently was liberal enough to offer a copy of his work on 'Elementary Astronomy' as a second prize. The following is the award :—

W. A. Smith.....SILVER MEDAL.

C. T. Blanshard.....Mr Lockyer's Prize.

D. H. Walsh.....*Honourable Mention.*

It is to be hoped that some generous donors will come forward to offer similar prizes in future years. The present competition has been so satisfactory, and so creditable to those who entered for it, that it can hardly be without a good effect on the general work of the Society. Such encouragements as these form a real incitement to study, and the offer of new prizes would probably show as its results a more extensive competition, and even higher excellence. We earnestly hope that we shall be soon able to announce a promise of prizes for the year 1872.

The following is the paper by W. A. Smith, for which a prize medal was awarded to him :—

* Now W. B. Woodforde.

THE SPECTRUM.

Of all the discoveries made within the last few years, none has deserved more attention, or more admiration, than the results of the application of spectrum analysis to Chemistry. We are now able to decide, with positive certainty, about the existence of certain elements in various bodies; and not only so, but even to mention without a doubt many of the substances contained in the sun and in the stars, while the composition of those mysterious nebulæ has to a great extent been revealed. But we know comparatively little to what we shall some day probably know. Every year brings some new discoveries to light. Within a very short time, four new elements have, by the aid of the spectrum, been discovered, namely, Indium, Caesium, Rubidium, and Thallium. When we consider the distance of the sun, and the almost incredible distance of the nearest fixed star from our earth, it seems more than wonderful that we should be able to learn so much about such bodies. We must, therefore, look upon the discovery of spectrum analysis as one of the most remarkable that has ever been made, and try to make good use of it.

Let us first examine into the appliances of the spectroscope to terrestrial matters. Before doing so, however, we must inquire into the nature of light and the construction of the instrument.

There are two theories about light. The first is the Emission or Corpuscular Theory, supported so strongly by Newton. The second is the Undulatory Theory, which has been advocated and established by Young. On the first, it is assumed that luminous bodies emit, in all directions, an imponderable substance consisting of molecules, which are propagated in right lines with an almost incredible velocity. These penetrate the eye, act on the retina, and determine the sensation which constitutes vision. On the undulatory theory, all bodies, as well as the celestial spaces, are filled with an extremely subtle elastic medium, which is called the luminiferous ether. The luminosity of a body is due to an infinitely rapid vibratory motion, which calls forth vibrations of the ether, which are propagated in all directions, and on striking the retina produce the sensation of vision. This theory is now almost universally held, as it explains many phenomena which the other could not. Light, heat, and sound are the three great vibratory motions; and I shall try in this paper to point out analogies between them whenever an opportunity offers.

In the year 1675, Sir Isaac Newton brought his famous treatise on 'Opticks' before the Royal Society. He heads the first paragraph in his memoir, 'Lights which differ in colour differ also in refrangibility.' This he showed by decomposing the white light of the sun. He allowed a pencil of solar light to pass through a

hole in a shutter into a dark room, and then examined it after it had passed through a triangular piece of glass called a prism. He found it was decomposed into lights of various colours, passing from red through all the shades of orange, yellow, green, blue, and violet. He also found that these rays could be again resolved into white light, and this he showed by allowing the coloured band to pass through an inverted prism. If, however, we cut off a portion of the spectrum which has passed through the first prism, on emerging from the second it will have undergone no alteration. The green rays, for example, will still appear green. But not only does the mixture of all the coloured rays give white light, but different other mixtures are found to produce the same result. Thus, violet and greenish yellow, indigo and yellow, blue and orange, greenish blue and red, and blue, orange, and red, give, when mixed, white light. It was once believed that the colours of the spectrum overlapped each other,—that is to say, it was composed of three principal colours, red, yellow, and blue, and that orange, green, and violet were formed by the overlapping of red and yellow, yellow and blue, blue and red respectively. But this has been found not to be the case, for the green, or orange, or violet, cannot be decomposed into any other colours.

Now, why is it that the eye can distinguish different colours? As light is a wave motion, we conclude that different colours are caused by different undulations of the elastic medium pervading all space. And here we may compare sound to light. As sounds of different pitch and intensity are caused by different rates and amplitudes of vibrations respectively, so are different colours and shades produced. But we know that sound travels at the rate of 1090 feet per second in air (at 0° C.), and is not transmitted at all in vacuo, whilst light travels at the enormous velocity of 190,000 miles a second. The wave length of the red ray A* just visible to the eye is $\frac{271}{10,000,000}$ of an inch, and in one second no less than 458,000,000,000,000 vibrations occur. The wave length of the violet ray H is $\frac{155}{10,000,000}$ of an inch, and 727,000,000,000,000 vibrations occur in one second. Hence the difference is only from 458 to 727, or the rapidity of vibration at the one point is not twice as great as it is at the other, so that, although the human ear is capable of hearing about eleven octaves, the eye cannot see even one. Nevertheless, there exist rays beyond the red and violet which we call obscure. It seems a strange fact, but still it is true, that half the rays of the sun reaching the earth are invisible. If we pass the rays coming from the electric light or from

* From the difficulty of procuring coloured illustrations of the spectra, it has been necessary to omit them; but the letters here given refer to the excellent plate in Mr Roscoe's 'Elementary Chemistry,' a work readily accessible to our readers.—Ed.

the sun through a solution of iodine in bisulphide of carbon, the luminous rays will be dissolved; and by lenses properly placed, we can burn a piece of paper with the invisible or obscure rays. The heat of these rays can also be well shown by the thermo-electric pile. If we pass this delicate instrument through the various colours of the spectrum, we see that, whilst the most intense light is in the yellow, the greatest heat is in the red, and that there is very little of either in the blue or violet. But these rays have chemically active properties,—that is to say, they have the power of decomposing, for example, silver salts. This is a most important fact in photography. It can easily be shown that the red rays have no chemical power, while the blue and violet have a great amount, by placing two sensitized plates, one in the violet and the other in the red rays. The former will be acted upon, but not the latter. The same phenomenon can be seen by the following experiment:—Place an electric light in a lantern with four coloured glass sides, and hold in front of the red side a bulb containing hydrogen and chlorine in equal proportions, the two gases will combine with a flash (forming hydrochloric acid) owing to the heat;* but if we place another bulb in front of the blue side, the two gases will unite with such force that the glass bulb will be shattered. It has been a very interesting work to physicists to find out by experiments the extent of chemically active solar rays in different parts of the globe, and very curious results have been obtained. It has been asserted that it requires a longer time to fix an image in photography under a burning tropical sun, than in the gloomier streets of London; and that from twenty minutes to half-an-hour was required in Mexico, where the light is very intense, to produce photographic effects which in England occupied a minute. Observations made at Para have shown what sudden changes take place in a very short time in the power of the chemical rays.

Having learned so much about the properties of the different rays, let us examine the construction of the spectroscope. There are various forms of this instrument, but it will be necessary to describe only a moderately simple one, as made by Steinheil of Munich.† It consists of a prism (*a*) fixed upon a strong iron stand, and a tube (*b*) carrying the slit (*d*), through which the rays from the coloured flames (*e* and e^1) fall upon the prism, being rendered parallel by passing through a lens. The light having been refracted, is received by the telescope (*f*), and the image

* The description here given of the action of light on a mixture of hydrogen and chlorine is incorrect, as no action takes place when the actinic rays are stopped by red glass.—*Note by the Examiner.*

† There is a figure of the instrument here described in Roscoe's Spectrum Analysis, and the letters refer to it.

magnified before reaching the eye. The rays from each flame are made to pass into the telescope (*f*); one set through the upper uncovered half of the slit, the other by reflection from the sides of the small prism (*c*) (which cannot be seen in the figure), through the lower half, thus bringing the two spectra into the field of view at once, so as to be able to make any comparison we like of the lines. The small luminous gas flame (*h*) is placed so as to illuminate a fixed scale contained inside the tube (*g*); this is reflected from the surface of the prism (*a*) into the telescope, and serves as a means of measuring the position of the lines. (*Roscoe.*)

Now, let us observe the spectra of various substances. Every different chemical element heated to luminosity gives off a peculiar light, which cannot in many instances be distinguished by the eye, but can with the greatest ease by the spectroscope. For example, when a potassium and rubidium salt are placed in a clear flame, they both yield a purple colour, which appears of the same tint; but when placed in the spectroscope, we see that potassium gives a violet and two red lines, while rubidium gives two violet, besides a great number of green and red. In examining any substance, it is best to heat the chloride in a colourless Bunsen's flame, as this salt is generally the most volatile compound. Let us first look at the spectrum of sodium. This is the most delicate of all. It has been calculated that $\frac{1}{2,000,000}$ part of a milligramme, or $\frac{1}{280,000,000}$ part of a grain, of soda can easily be detected. Soda is always present in the air, existing in almost every speck of dust, and occurring most abundantly in sea-water and several mines in the form of chloride. Whenever we clap our hands in front of a Bunsen's flame, we observe a yellow colour in it. This is due to sodium. There is only one line, *Na a*, characteristic of it, which is coincident with Fraunhofer's dark line D, and is remarkable for its exactly defined form, and for its extraordinary degree of brightness. (I shall speak further on about Fraunhofer's lines.) If the temperature of the flame be very high, and the quantity of the substance employed very large, traces of a continuous spectrum are seen in the immediate neighbourhood of the line.

Lithium, which was before considered to be a most rare and scantily distributed substance, is now seen to exist in a great number of bodies, though in very small quantities; being found in the juice of plants, grapes, tea, coffee, milk, human blood, muscular tissue, meteoric stones, the water of the Atlantic, many rivers, mineral waters, and the ashes of tobacco, besides in a great many minerals. $\frac{1}{100,000}$ part of a milligramme, or $\frac{1}{6,000,000}$ part of a grain, can easily be detected. There are two lines which characterise the spectrum of lithium; the one a very weak yellow line, *Li β*, and the other a bright red line, *Li a*. When the temperature is very high a beautiful blue line is seen; and it must here be noticed that the

other two lines never change their position, whatever may be the temperature to which the vapour is raised. Whenever substances are mixed together, the spectrum of neither is spoiled, but the most volatile body gives the first appearance of its lines.

Potassium, when placed in the flame, gives two characteristic lines, namely, one line, K α, in the outermost, red, approaching the ultra red rays, exactly coinciding with the dark line A of the solar spectrum; and a second line, K β, situated in the extreme violet rays, and also identical with a particular dark line observed by Fraunhofer. There is also another very indistinct line, coinciding with the dark line B, but this is seen only when the light is intense, and is by no means characteristic. In order to detect the presence of potassium, the eye requires $\frac{1}{1000}$ of a milligramme of potassium (chlorate).

Strontium has a much more complicated spectrum than any of the former substances; in fact, all the alkaline earths have. In it there are eight lines remarkable, six red, one orange, and one blue. There are no green bands present. $\frac{6}{100,000}$ of a milligramme, or $\frac{1}{1,000,000}$ of a grain, can be with certainty detected. Strontia has been shown to exist in very many limestones of different geological ages.

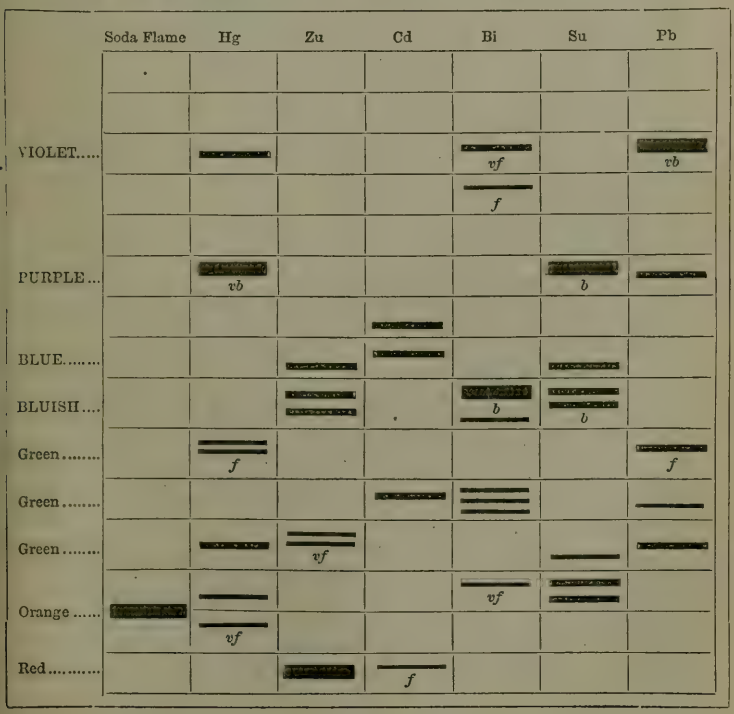
The spectrum of *calcium* is particularly marked by the very bright green line Ca β. There is also a very bright orange line Ca α, nearer the red end of the spectrum than either the sodium line, Na α, or the orange band of strontium, Sr α. There are several other lines, but they are not of so much importance as the other two lines. In order to see these lines, the eye requires just as much calcium as strontium.

Of all the alkalies and alkaline earths, *barium* has the most complicated spectrum. It can easily be distinguished by the green lines Ba α and Ba β. These are by far the most distinct. Ba γ, although not so distinct, is nevertheless a well-marked and peculiar line. About $\frac{1}{1000}$ of a milligramme of a barium salt may be detected with the greatest certainty.

The spectra of caesium, rubidium, and potassium present a striking analogy in their appearance. They each possess a spectrum which is continuous in the middle, showing that a substance could give out rays of every degree of refrangibility. *Rubidium* shows two splendid blue lines, two beautiful red lines, besides several in the green and orange. *Caesium* gives two characteristic blue lines, which are not so near the violet end as those of rubidium. Not long after the discovery of the two new alkalies, Mr Crookes, in examining the deposit of the flue of a pyrites burner, found a new substance, which he called *Thallium*, owing to the splendid solitary green line which it gives. It is not difficult to obtain the metal from its salts.

Indium was discovered in 1864. Its spectrum is characterised by two lines only, one in the violet and the other in the blue.

Whenever we wish to analyse metals proper or heavy metals, it becomes a more difficult matter, as the heat of the Bunsen's flame will in most cases be found not to be strong enough. We have recourse then to electricity. By means of an induction-coil and a battery we can obtain a spark sufficiently strong to volatilise the metals. But how does this take place? It was fully proved by Faraday that electric sparks consisted partly of the material of the poles, and partly of the air and moisture of the air in a high state of ignition. In this way we may also get the spectrum of the gases constituting our atmosphere. Every gas gives lines peculiar to itself; and if there is a considerable amount of carbonic dioxide in the air, we may even get the spectrum of this. Wheatstone has drawn several of the lines which various metals give, although there are a very great number. *Vb* signifies very bright, *b* bright, *f* faint, and *vf* very faint.



Professors Kirchhoff, Angström, and Thalén, and Mr Huggins have made very accurate maps of the metallic lines. In the latter's map several of the bright lines appear to coincide, namely—

	Division of Scale.		Division of Scale.
Zinc and arsenic, . .	909	Tellurium and nitrogen, .	1366
Sodium and lead, . .	1000	Osmium and arsenic, .	1737
Sodium and barium, .	1005	Chromium and nitrogen,	2336

I have no doubt that with more accurate instruments these lines will appear to be perfectly distinct, yet it appears truly wonderful that, in examining many hundreds of bright lines of twenty-four elements, Huggins found only six cases of coincidence.

Now we come to the examination of the spectra of gases and other non-metallic bodies. We again have recourse to electricity. Angström was the first to point out that the ordinary electric spark, in passing between the poles in air, yields a double spectrum—one of the metallic poles, and the other of the air. If we diminish the density of the gaseous medium through which the spark passes, we can get a much longer one ; we thus obtain the beautiful phenomenon of the discharge in vacuo. By filling tubes with different gases, and then nearly exhausting them by the air-pump, we obtain lights of different colours. The well-known Geissler's tubes are made on this principle. When the electricity passes through, the gas becomes heated to incandescence, and we can thus easily obtain its spectrum.

Hydrogen gives a peculiar red colour, and it is characterised by three bright lines—one of the most intense red, another of a bright greenish blue colour, and the third a dark blue or indigo. These same three lines coincide exactly with three dark lines in the solar spectrum, and we shall presently see that it has been established without a doubt that hydrogen exists in the solar atmosphere. The spectrum of nitrogen is much more complicated. It consists of a great number of lines in the blue and violet, green and red. It has been found that it undergoes a change when the intensity of the electric discharge varies, and when highly rarified nitrogen is used, not when it is at the ordinary atmospheric pressure. It has been explained by saying that nitrogen, as oxygen, exists in allotropic modifications.

When intensely heated, and under certain circumstances, gaseous bodies can be made to yield continuous spectra, and certain elements on an increase of temperature give new lines. We may compare with this phenomenon the overtones or harmonics of a vibrating string, as observed in acoustics.

The examination of the spectrum of carbon is of great interest

and importance, and it has been found that different compounds of this element, when raised to the state of incandescent gas, give somewhat different spectra. For example, cyanogen (CN) yields several lines which common coal-gas does not, among which are several blue and red. The knowledge of the carbon spectrum has been put to good use in the manufacture of steel by the Bessemer process. Steel differs from cast-iron in containing less carbon, and this is actually burnt out by allowing a stream of air to pass through the cast-iron when in a molten state. The flame which is given off is peculiar, and, by observing it with the spectroscope, we can tell the moment at which the operation must be stopped. The exact point at which this must be done is when the carbon lines disappear and the spectrum becomes continuous. If we allow it to go on a little longer than is proper, we shall obtain the steel so viscid that it cannot be poured out of the ladle ; if, on the other hand, we stop too soon, the iron will contain so much carbon that it will be too brittle for use. Among the substances in the Bessemer flame, sodium, potassium, silicon, iron, carbon, hydrogen, and nitrogen have been detected.

It has long been known that certain bodies have, at the ordinary temperature, the power of selecting a certain kind of light and absorbing it. This is called selective absorption. For example, when *white light* passes through the violet vapours of iodine, or red nitrous fumes, dark bands will be seen. Some coloured gases do not give any bands, while other colourless gases give spectra full of dark lines. The solutions of many salts give very peculiar bands, especially didymium, which can be detected in this way with the greatest ease. Blood also gives very curious bands. Cruorine gives quite a different absorption spectrum from hæmatin. And there is a very interesting fact connected with this subject. Poisoning by CO_2 can be readily detected, owing to the different spectra which pure blood and that containing carbonic dioxide produce. Dr Herapath of Bristol, in concluding a pamphlet entitled, 'On the Use of the Spectroscope and Microspectroscope in the Discovery of Blood-stains and Dissolved Blood, and in Pathological Inquiries,' says, 'Although spectrum analysis does not go one step farther than we were before in our powers of discriminating human blood from that of other mammalian or red-blood creatures, yet it gives us greater facilities of demonstrating the presence of the colouring matter of blood, even in inconceivably minute and almost invisible proportions, whilst the facility with which the observations are made is a great, if not the greatest, recommendation to the employment of this method whenever practicable.'

It is a well-known fact in optics that some substances, as the

diamond, fluorspar, &c., have the power of absorbing, when exposed to a very bright light, a certain quantity of these rays, and again of radiating or giving them out when placed in a dark room. Becquerel has examined the spectra of various substances under these circumstances, and has found that the light emitted by them is peculiar in this way, that they yield broken spectra, or bands of differently coloured rays. Alumina, for example, in this state of *phosphoresence* emits a red light, and its spectrum exhibits four bands between the lines C and H in the solar spectrum.

There is another interesting property which certain bodies possess, when exposed especially to the blue rays of the solar or electric spectrum, namely, *fluorescence*. If a piece of Uranium glass, for example, is held in the violet rays, it appears self-luminous. This is caused by the transmutation of the rays into others, which are always of lower refrangibility.

We come now to a most interesting and instructive part of this subject—namely, solar and stellar chemistry. The electric spectrum is made up of continuous bands, but in the solar dark lines are observed. These are called Fraunhofer's lines, from the name of the person who first mapped some of them out, and investigated the subject. The mapping of these lines is of the highest importance, as, by their means, we can tell that some substances, as iron, sodium, and magnesium, are present in the sun, and also in the fixed stars. We do not know the composition of the planets, or of the moon, because their light is reflected to us from the sun, and consequently give the solar spectrum. But the fixed stars give partly different lines; hence we conclude that these lines are not due to our atmosphere, but to the substances existing in the sun and stars.

So long ago as 1814, Fraunhofer concluded that these lines were caused by some absorptive power exerted in the stars or sun.

And not only do these dark lines exist in the visible portions of the spectrum, but they also occur in the portions which contain the visible heating and chemically active rays. This can be shown in the ultra-violet rays, but not in the ultra-red, by placing a sensitized collodion plate in the former, when shaded spaces will be produced, indicating the positions in which the intensity of the rays is small. These are Fraunhofer's lines in the ultra-violet sunlight.

We now come to the important inquiry about the lines. How are they formed? Fraunhofer observed, many years ago, that the dark lines D in the solar spectrum were coincident with the bright sodium lines; but it was not till the year 1859 that Kirchhoff explained the phenomena thoroughly. He obtained a strong solar

spectrum, and placed in front of the slit a Bunsen's flame, coloured with the vapour of sodium. The dark lines D were immediately changed into bright lines. He then wished to see how strong the solar spectrum could be made without impairing the distinctness of the sodium lines, and, for this purpose, he allowed a beam of sunlight to fall on the slit, after passing through the sodium flame. He was greatly astonished at finding the dark lines reappear as clear as possible. He then allowed the lime-light to fall through a flame coloured with sodium, and he observed dark lines in the spectrum in the position of the sodium lines. From these experiments, and their results, he concluded that the sodium flame absorbs rays of the same degree of refrangibility as those it emits, whilst it is perfectly transparent for all other rays. If we heat some sodium behind a sodium flame, the flame will appear smoky, and will give the dark lines D in the spectrum. If, however, we ignite some lithium salt behind the flame, the red colour will appear, and the spectrum will show both the sodium and the lithium bright lines. Kirchhoff then states that it appears likely that glowing gases have the power of absorbing rays, especially of the same degree of refrangibility as those they emit; and so that the bright lines can be changed into dark ones by allowing a sufficiently intense light, giving a continuous spectrum, to pass through it. Many other substances besides sodium have had their flames reversed, by experimenting in exactly the same way. We may compare to this power which certain substances have of absorbing the same sort of rays which they emit, the phenomenon in acoustics known as resonance, in which a certain column of air takes up and reinforces a certain set of vibrations. The presence of these dark lines in the solar spectrum is a positive proof of the existence of various substances. It is almost an impossibility that they should be caused by our atmosphere, because it could not contain enough iron vapour to cause such distinct absorption lines in the spectrum; and, besides this, it is noticed that these lines do not appreciably alter when the sun approaches the horizon.

As soon as the existence of one terrestrial substance in the sun's atmosphere was established, it seemed but natural that other bodies should be present also. Experiments have been made, and the following metals have been found to have their dark representatives in the sunlight:—

1. Sodium.	5. Iron.	9. Zinc.	13. Hydrogen.
2. Calcium.	6. Chromium.	10. Strontium.	14. Manganese.
3. Barium.	7. Nickel.	11. Cadmium.	15. Aluminium.
4. Magnesium.	8. Copper.	12. Cobalt.	16. Titanium.

The sun most probably, as Kirchhoff says, consists of a solid or

liquid nucleus, heated to a temperature of the brightest whiteness, which is surrounded by an atmosphere of somewhat lower temperature. Within the last two or three years we have obtained some knowledge about the mysterious red protuberances which are seen on the circumference of the sun at the time of an eclipse. From experiments made with the spectroscope, they appear to consist of hydrogen in a state of ignition. It is supposed that they sometimes reach the height of 80,000 or 90,000 miles.

Let us now glance at the properties of the light from the fixed stars. By proper instruments, physicists have been enabled to learn as much about the atmosphere and the physical constitution of the stars, as about the composition of the solar atmosphere. But still it has been acquired by much toil and labour. As the light emitted by the stars is very feeble, most delicate instruments are required, which have to be constructed with the greatest care and expense. The spectra of several stars have been examined. In Aldebaran two hydrogen lines, C and F, are present, but in α Orionis these are absent, therefore it is concluded that hydrogen is present in Aldebaran, but absent in α Orionis. In the same way it is seen that silver is not present in Aldebaran, nor in α Orionis, but that four bright lines of calcium, also seen in the sun's spectrum, are present in both stars. In Aldebaran no less than nine elements have been detected, namely :—

1. Hydrogen.	4. Calcium.	7. Tellurium.
2. Sodium.	5. Iron.	8. Antimony.
3. Magnesium.	6. Bismuth.	9. Mercury.

We see that four elements are thus found in Aldebaran which do not exist in the sun. All the stars observed contain hydrogen, except Betelgeux and β Pegasi. Different coloured stars give spectra in which there is a greater absence of dark lines in the rays which are of the same colour as the stars than in the other parts. It is interesting to know that the spectra of fixed stars contain, like the solar light, invisible chemically active rays. Mr Huggins has photographed the spectrum of Sirius. The intensity of the light of this star has been calculated to be about the $\frac{1}{6,000,000,000}$ of that of the sun ; and although probably not less in size than sixty of our suns, the distance of it from our earth is estimated to be more than 130,000,000,000,000 miles! And yet, at this great distance, we can register the chemical intensity of the rays which left Sirius twenty-one years ago. Mr Huggins has also examined those mysterious bodies the nebulæ, and has found that, instead of having bands of light intersected by dark lines, the spectra consist of bright lines. The conclusion we arrive at from this is, that these bodies do not consist of a white-hot nucleus, sur-

rounded by a glowing atmosphere; but, on the contrary, that these nebulæ are in the condition of luminous gases, and that it is really nebulous matter with which we have to deal.

In concluding this short and imperfect paper on spectrum analysis, I cannot do better than quote Roscoe's words at the end of his splendid book, from which I have obtained a great amount of information.

'Who could have dreamt, ten years ago, that we should so soon attain such an insight into the processes of creation? And yet, great though the results of spectrum analysis already are, they are but a tithe of the numerous questions which this branch of discovery has opened up—questions of such number and magnitude, that many generations of men will pass away before they are all satisfactorily answered.'

In fact, I may add, that it promises to enable us, in the words of the Poet Laureate—

> 'To follow knowledge like a sinking star,
> Beyond the utmost bound of human thought.'

REPORT OF THE CURATOR OF THE MUSEUM AND BOTANIC GARDEN.

The Museum and Botanic Garden of Clifton College were first projected in the spring of 1870, and towards the end of that year, a fund was begun with a view to defray the cost of their formation and maintenance. As will be seen by the subjoined balance-sheet, a large sum has now been raised, and though the expenses have been necessarily heavy, the subscribers will be glad to know that both the Garden and the Museum are now *entirely free of debt.*

The Museum has been somewhat fully described on pages 46 and 47 of the present Number of Transactions. It is still in its infancy, but though there are many gaps in the collections, some of them are already remarkably good. The series of British Lepidoptera, for instance, is very complete, and we have a splendid set of mineral specimens. I shall state very briefly the present condition of each portion of the Museum, as I can thus show more readily what has been done and what is still required. Before doing so, however, I must call attention to an important rule which we laid down at the very outset: "The Museum shall be

essentially a British one, and shall illustrate the Natural History and Antiquities of our land by good specimens, systematically arranged, under the departments of Zoology, Botany, Geology, Mineralogy, and Archæology. In addition to this, there will be a collection of rare and curious objects, which may be considered useful for the purposes of scientific teaching, and a large typical series to be used at the lectures and demonstrations given in the College on Comparative Anatomy and other branches of Natural History. The Committee of Management will only accept of such specimens as can be classed under some one of these heads." To this rule we have hitherto adhered absolutely, and I feel little doubt that its adoption will insure the real utility of the Museum, and will make the collections much more perfect than could otherwise be expected.

Professor Sedgwick sent us last spring one of the best typical collections of mesozoic fossils that I have ever seen (*vide* p. 31). The gift is in every way most valuable, and it is one of the most useful that the Museum has yet received. The palæozoic fossils were very imperfectly represented till lately, when a large case was received from the Director-General of the Irish Geological Survey, E. Hull, Esq., F.R.S. Both to him and to W. H. Baily, Esq., Palæontologist to the Survey, our best thanks are due for this welcome donation. The specimens are mostly typical, and are all named. Some of them are of great rarity.

We are further indebted for large collections of fossils to Samuel Worsley, Esq., of Clifton, and there have been very many other contributors as well. The *local series* of fossils I consider of especial importance in such a Museum as ours. It is under the superintendence of J. G. Grenfell, Esq., by whose efforts it has already attained considerable dimensions. The expeditions of the Geological Section have been the means of procuring large accessions to this collection; and among individual donors mention should especially be made of J. Rossiter, Esq., and S. G. Perceval, Esq.

The rock specimens are as yet few and unimportant, but Professor Phillips, of Oxford, has promised to give us shortly a number of duplicates from the splendid collection in the Museum of the University of Oxford. The kindness of a Clifton lady (Miss Wills) has lately furnished the Museum with a complete series of

polished cubes (101 in number), illustrating the rocks of the Avon section at Clifton. They are arranged (in stratigraphical order) in one of the glass cases, and a complete catalogue of them has been prepared for the use of students.

The minerals of our Museum are both numerous and valuable, comprising not less than one thousand different kinds. The greater portion of them was lately acquired through the following circumstances. W. Sanders, Esq., F.R.S., wishing to dispose of a large mineral collection which he had been forming for many years, kindly offered it to us at a sum which represented but a small portion of its real value. He further offered to give one-third of the amount as a donation from himself. The Rev. J. Heyworth, Chairman of the College Council, on hearing of Mr Saunders' offer, generously contributed another third; and thus, for the small contribution of *ten pounds* from our funds, we have been able to procure a very extensive and excellent set of minerals. Mr Grenfell and myself are preparing a catalogue of the collection, and we hope shortly to issue it.

We have a very large collection of shells. They are arranged in three series, *i.e.*—(1.) British Land and Fresh-water Shells; (2.) British Marine Shells; (3.) Generic Examples from all parts. Woodward's "Manual of the Mollusca" has been used in arranging them, and they are now in excellent order. A. Cruttwell, Esq., O.C., was one of the largest contributors to this department, but valuable gifts have been made to it by many others. We offer a considerable number of duplicate specimens for exchange.

The following report on the Lepidoptera of the Museum has been drawn up by the Rev. J. Greene:—

Considering that the collection of British Lepidoptera was only commenced within the present year (1871), its condition is very satisfactory. It comprises four hundred species, thus divided:—

Diurni, ...	46	Noctuæ, ...	145
Nocturni and Bombyces, ...	66	Pyrales	15
		Geometræ	128

The number of specimens is over twelve hundred, about nine hundred of which have been presented by the Rev. J. Greene. The collection is also greatly indebted to the following ladies and gentlemen for liberal donations—viz., Mrs Hutchinson, of Grantsfield, Leominster; Mrs Battersby, Cromlyn, Rathowen, Ireland; E. Birchall, Esq., Newlay, Leeds; Mr G. Corbin, Ringwood, Hants; Rev. E. N. Bloomfield, Guestling Rectory, Chichester; Rev. H. G. Aubrey, Hale Rectory, Salisbury; Mr G. Baker, Derby; and G. Lock, Esq., Newport.

To give a complete list of all the species contained in the collection would obviously occupy too much space. I have therefore only enumerated some of the rarer and more interesting insects. The initials of the various donors are prefixed, thus :—

Mrs H. . . . Mrs Hutchinson.	E. N. B. . . . E. N. Bloomfield.
Mrs B. . . . Mrs Battersby.	H. A. . . . H. Aubrey.
E. B. . . . Edwin Birchall.	G. B. . . . G. Baker.
J. G. . . . Joseph Greene.	G. L. . . . G. Lock.
G. C. . . . G. Corbin.	

LIST OF SPECIES.

J. G. Papilio machaon, a bred series.
G. L. Pieris cratægi, a fine series.
J. G. Colias edusa.
J. G. hyale.
Mrs H. & Mrs B. Vanessa C. album, a fine series.
G. C. Limenitis sibylla.
J. G. Apatura iris.
E. B. Erebia cassiope.
E. B. Chortobius davus.
J. G. Thecla pruni.
J. G. betulæ.
J. G. Lycæna arion.
E. B. Thanaos actæon.
J. G. Acherontia atropos.
J. G. Sphinx convolvuli.
Mrs B. Chœrocampa elpenor.
E. B. Sesia philanthiformis, a fine series.
E. B. Zygæna minos.
E. N. B. Lithosia mesomella.
E. N. B. aureola.
E. N. B. pygmæola.
J. G. helveola.
G. C. Eulepia cribrum.
J. G. Orgyia cœnosa.
E. N. B. Bombyx castrensis.
J. G. Endromis versicolor.
J. G. Ptilophora plumigera, a bred series.
J. G. Notodonta cucullina, bred.
J. G. carmelita, do.
J. G. chaonia, do.
H. A. dodonæa, do.
E. B. Cymatophora diluta.
E. B. Cymatophora flavicornis, bred.
J. G. ridens, do.
J. G. Dipthera orion, do.
J. G. Acronycta strigosa.
J. G. myricæ.
J. G. Simyra venosa, bred.
E. B. Mamestra albicolon.
J. G. Tæniocampa opima, a bred series.
E. N. B. populeti.
E. N. B. miniosa.
Mrs H. gracilis.
J. G. munda, a bred series.
J. G. Orthosia suspeta.
J. G. Hoporina croceago, a bred series.
J. G. Xanthia aurago, do.
G. B. gilvago, do.
J. G. Cirrædia xerampelina, do.
E. B. Euperia fulvago.
J. G. Dianthœcia carpophaga, a bred series.
J. G. & E. B. capsophila.
J. G. cucubali.
J. G. Epunda lutulenta.
J. G. nigra.
J. G. Hadena genistæ.
E. B. Calocampa vetusta.
J. G. exoleta.
J. G. Xylina semibrunnea.
J. G. Heliothis marginata.
J. G. peltigera.
Mrs B. Hydrelia unca.
J. G. Abrostola triplasia, a bred series.
J. G. Catocala promissa.
J. G. sponsa.
J. G. Selenia illustraria.
J. G. Ennomos fuscantaria.
J. G. erosaria, a bred series.
Mrs B. Biston hirtaria, do.
J. G. Boarmia consortaria.
J. G. Iodis vernaria, a bred series.
J. G. Acidalia holosericeata.
J. G. Aleucis pictaria.
J. G. Scoria dealbata.
J. G. Emmelesia tæniata.
J. G. unifasciata.
J. G. ericetata.
J. G. blandiata.
J. G. Eupithecia consignata, bred.
J. G. pulchellata, do.
J. G. isogrammata, do.
J. G. helveticata, do.
J. G. satyrata, do.
J. G. albipunctata, do.
J. G. valerianata, do.
J. G. pimpinellata, do.
J. G. abbreviata, do.
J. G. Collix sparsata.
J. G. Thera simulata.

Most of the specimens are in good condition, many of them, as will be seen from the above list, being bred.

I have only, in conclusion, to return my sincere thanks to those who have generously assisted us by their donations; and I think, if they could see the collection, they would not consider them ill bestowed.

J. Greene.

The Coleoptera are represented by a great number of specimens, and the arranging and labelling of them has been very kindly undertaken by Mr Barton, an experienced coleopterist. Professor Westwood, of Oxford, is the contributor of one-half of these insects, and he has given so much time and trouble to their selection and naming, that our very warmest thanks are due to him. J. F. M. H. Stone is also the donor of a large proportion of the whole collection. In other departments of the insect world we have very few examples.

The British eggs are numerous and well arranged. Of stuffed British birds, too, we have a good many specimens. The following are lists of them, written mainly by J. F. M. H. Stone and P. A. Ogilvie :—

BRITISH BIRDS' EGGS.

Hobby, *Falco subbuteo.*
Kestrel, *Tinnunculus alaudarius.*
Sparrowhawk, *Accipiter Nisus.*
*Rough-legged Buzzard, *Buteo lagopus.*
*Long-eared Owl, *Otus vulgaris.*
*Tawny Owl, *Syrnium aluco.*
Red-backed Shrike, *Lanius collurio.*
*Woodchat Shrike, *Lanius auriculatus.*
Spotted Flycatcher, *Muscicapa grisola.*
Missel Thrush, *Turdus viscivorus.*
Song Thrush, *Turdus musicus.*
Blackbird, *Turdus merula.*
Ring Ouzel, *Turdus torquatus.*
Hedge Accentor, *Accentor modularis.*
Redbreast, *Erythaca rubecula.*
Redstart, *Ruticilla phœnicurus.*
*Whinchat, *Pratincola rubetra.*
*Wheatear, *Saxicola Œnanthe.*
*Sedge Warbler, *Salicaria Phragmitis.*
*Reed Warbler, *Salicaria strepera.*
*Nightingale, *Philomela luscinia.*
Blackcap, *Sylvia atricapilla.*
Garden Warbler, *Sylvia hortensis.*
Whitethroat, *Sylvia cinerea.*
*Lesser Whitethroat, *Sylvia curruca.*
*Wood Warbler, *Sylvia Sibilatrix.*
Willow Warbler, *Sylvia Trochilus.*
Melodious Willow Warbler, *Sylvia hypolais.*
*Chiffchaff, *Sylvia rufa.*
Golden-crested Regulus, *Regulus cristatus.*
Greater Tit, *Parus major.*
Blue Tit, *Parus cœruleus.*
*Long-tailed Tit, *Parus caudatus.*
Pied Wagtail, *Motacilla Yarrellii.*
*Gray-headed Wagtail, *Motacilla flava.*
*Ray's Wagtail, *Motacilla campestris.*
Tree Pipit, *Anthus arboreus.*
Meadow Pipit, *Anthus pratensis.*
Sky Lark, *Alauda arvensis.*
Wood Lark, *Alauda arborea.*
Black-headed Bunting, *Emberiza schœniclus.*
Yellow Bunting, *Emberiza citrinella.*
Tree Sparrow, *Passer montanus.*
House Sparrow, *Passer domesticus.*
Greenfinch, *Coccothraustes chloris.*
Goldfinch, *Carduelis elegans.*
*Linnet, *Linota cannabina.*
*Lesser Redpole, *Linota linaria.*
Bullfinch, *Loxia Pyrrhula.*
Starling, *Sturnus vulgaris.*
Carrion Crow, *Corvus Corone.*
Rook, *Corvus frugilegus.*
Jackdaw, *Corvus Monedula.*
Magpie, *Pica caudata.*
Jay, *Garrulus glandarius.*
Green Woodpecker, *Picus viridis.*
Wren, *Troglodytes europæus.*
*Nuthatch, *Sitta cœsia.*
*Cuckoo, *Cuculus canorus.*
*Kingfisher, *Alcedo ispida.*
Swallow, *Hirundo rustica.*
*Martin, *Hirundo urbica.*
Sand Martin, *Hirundo riparia.*
*Swift, *Cypselus apus.*
*Goatsucker, *Caprimulgus europæus.*
Ring Dove, *Columba palumbus.*
*Stock Dove, *Columba œnas.*
Turtle Dove, *Columba Turtur.*
Pheasant, *Phasianus colchicus.*
Red Grouse, *Scoticus Lagopus.*
Partridge, *Perdix cinerea.*
*Golden Plover, *Charadrius pluvialis.*
*Ringed Plover, *Charadrius hiaticula.*

Little Ringed Plover, *Charadrius curonicus.*
Gray Plover, *Squatarola helvetica.*
Peewit, *Vanellus cristatus.*
*Redshank, *Totanus calidris.*
Common Snipe, *Scolopax Gallinago.*
Landrail, *Crex pratensis.*
Moorhen, *Gallinula chloropus.*
Coot, *Fulica atra.*
*Wild Duck, *Anas Boschas.*
*Teal, *Anas crecca.*
*Eider Duck, *Somateria mollissima.*
*Little Grebe, *Podiceps minor.*
Guillemot, *Uria troile.*
*Puffin, *Fratercula arctica.*
Razorbill, *Alca torda.*
Cormorant, *Phalacrocorax Carbo.*
*Common Tern, *Sterna hirundo.*
Arctic Tern, *Sterna macroura.*
*Lesser Tern, *Sterna minuta.*
Gull, *Larus canus.*
*Lesser Blackbacked Gull, *Larus fuscus.*
Herring Gull, *Larus argentatus.*
*Richardson's Skua, *Lestris parasiticus.*

The set of eggs is not complete of those marked with asterisk (*).

BRITISH BIRDS.

Red-footed Falcon, *Falco vespertinus.*
Rough-legged Falcon, *Archibutes logopus.*
Kestrel, *Tinnunculus alaudarius.*
Sparrow Hawk, *Accipiter Nisus.*
Montagu's Harrier, *Circus cineraceus.*
Long-eared Owl, *Otus vulgaris.*
Great Gray Shrike, *Lanius excubitor.*
Red-backed Shrike, *Lanius Collurio.*
Spotted Flycatcher, *Muscicapa grisola.*
Fieldfare, *Turdus pilaris.*
Redwing, *Turdus iliacus.*
Blackbird, *Turdus merula.*
Hedge Accentor, *Accentor modularis.*
Redstart, *Ruticilla phœnicurus.*
Stonechat, *Pratincola rubicola.*
Whinchat, *Pratincola rubetra.*
Sedge Warbler, *Salicaria phragmitis.*
Willow Warbler, *Sylvia trochilus.*
Chiffchaff, *Sylvia rufa.*
Fire-crested Regulus, *Regulus ignicapillus.*
Blue Tit, *Parus cæruleus.*
Bohemian Waxwing, *Bombycilla garrula.*
Pied Wagtail, *Motacilla Yarellii.*
Tree Pipit, *Anthus arboreus.*
Sky Lark, *Alauda arvensis.*
Short-toed Lark, *Alauda brachydactyla.*
Snow Bunting, *Plectrophanes nivalis.*
Bunting, *Emberiza citrinella.*
Cirl Bunting, *Emberiza cirlus.*
Chaffinch, *Fringilla Cœlebs.*
Tree Sparrow, *Passer montanus.*
House Sparrow, *Passer domesticus.*
Greenfinch, *Coccothraustes chloris.*
Goldfinch, *Carduelis elegans.*
Lesser Redpole, *Linola linaria.*
Crossbill, *Loxia curvirostra.*
Starling, *Sturnus vulgaris.*
Rook, *Corvus frugilegus.*
Jackdaw, *Corvus monedula.*
Magpie, *Pica candata.*
Jay, *Garrulus glandarius.*
Green Woodpecker, *Picus viridis.*
Great Spotted Woodpecker, *Picus major.*
Wryneck, *Yunx torquilla.*
Creeper, *Certhia familiaris*
Nuthatch, *Sitta europœa.*
Cuckoo, *Cuculus canorus.*
Kingfisher, *Alcedo ispida.*
Sand Martin, *Hirundo riparia.*
Stock Dove, *Columba œnas.*
Turtle Dove, *Columba turtur.*
Pheasant, *Phasianus colchicus.*
Black Grouse, male and female, *Tetrao tetrix.*
Red Grouse, male and female, *Lagopus scoticus.*
Partridge, *Perdix cinerea.*
Ring Plover, *Charadrius hiaticula.*
Lapwing, *Vanellus cristatus.*
Oyster Catcher, *Hæmatopus ostralegus.*
Little Bittern, *Botaurus minutus.*
Curlew, *Numenius arquata.*
Whimbrel, *Numenius phœopus.*
Redshank, *Totanus calidris.*
Common Sandpiper, *Totanus hypoleucos.*
Green Shank, *Totanus glottis.*
Ruff, *Machetes pugnax.*
Jack Snipe, *Scolopax gallinula.*
Water Rail, *Rallus aquaticus.*
Moorhen, *Gallinula chloropus.*
Ferruginous Duck, *Fuligula Myroca.*
Red-breasted Merganser, *Mergus serrator.*
Goosander, *Mergus Castor.*
Little Grebe, *Podiceps minor.*
Great Northern Diver, *Colymbus glacialis.*
Guillemot, *Uria troile.*
Puffin, *Fratercula arctica.*
Razorbill, *Alca torda.*
Common Tern, *Sterna hirundo.*
Arctic Tern, *Sterna arctica.*
Great Black-backed Gull, *Larus marinus.*
Smew, *Mergus albellus.*
Little Auk, *Mergulus alle.*

I have lately begun the formation of a 'Zoological Series,' intended to illustrate typically the leading forms of animal life, and I hope to make this one of the most interesting portions of the Museum, though our limited space will prevent it from becoming very extensive. An Osteological collection has also been undertaken, and it already contains some good specimens, amongst others a fine elephant's skull, procured for us in India by General M'Leod. Both the Osteological and the Zoological series will be of very great use in instruction, and I am anxious to receive additions to them.

The Coins form a large collection, and many of them are rare and valuable. W. Baillie and J. Prinsep have been arranging them for some time back, but there is much need of a good cabinet, which we cannot at present afford to purchase. R. Bamford, W. Hill, and A. Paul, Esq., O.C., have contributed largely to this department of the Museum.

A good Museum is of little use without a good scientific Library, and we have therefore purchased a considerable number of standard works of reference, mostly illustrated, for the use of our students. A welcome addition to the scientific Library has lately been made by Thomas Proctor, Esq., whose generous donations to the Museum and Garden have been most munificent. The naming of fossils had hitherto been a difficult task, from the want of good drawings for comparison and reference, but this want Mr Proctor has now supplied, by furnishing us with an entire set of the Palæontographical Society's publications. F. F. Tuckett, Esq., has also presented many useful scientific books to the Library.

The Herbarium is at present placed in the Museum, suitable drawers having been provided for it. It is now of considerable extent, and most of the plants are uniformly mounted on stiff paper, and labelled. The nucleus of the collection was an old, but most extensive herbarium, formed by the late Miss Mills, and contributed by her nephew. The Rev. James Heyworth has lately given us a very large number of specimens, collected by himself, together with another series made by Mr Thwaits, of Ceylon. Mr Heyworth's gift is especially rich in ferns and seaweeds. We propose to make a local herbarium during the coming season.

It remains to say something of the Botanic Garden. As may be seen by the announcement of donations made at the Scientific

Society's meetings, the gifts to it have been very numerous. I have to express my especial thanks to the following institutions and private individuals, who have given me the most zealous help in the formation of this Garden :—Royal Botanic Gardens, Edinburgh (Prof. Balfour) ; Trinity College, Dublin (Prof. Percival Wright) ; Royal Botanic Gardens, Regent's Park, London (W. Sowerby, Esq.) ; Royal Botanic Gardens, Glasnevin (Dr Moore) ; Botanic Gardens, Hull (J. C. Niven, Esq.) ; Rev. H. N. Ellacombe, Bitton ; J. Saunders, Esq., Clifton ; George Maw, Esq., Broseley ; J. Backhouse, Esq., York ; T. Proctor, Esq., Clifton. Further donations are promised this spring by Dr Hooker, Kew ; Professor Lawson, Oxford ; Professor Babington, Cambridge ; and J. Richardson, Esq., Liverpool.

The formation of the Garden was a work of considerable difficulty, the place assigned for it being exceedingly barren and unpromising. However, T. Proctor, Esq., with his usual generosity, gave us a great quantity of excellent top-soil, and the ground having been thoroughly drained and prepared by Mr Nelson during the winter of 1870-71, was made ready for the reception of plants in the following spring. The garden is divided by a path into two portions, each with a neat iron fence. The hedges are formed of the following shrubs :—*Berberis Darwinii, Spartium junceum, Ulex Europæa fl. pl., Prunus Lauro-cerasus, var. Colchica, Rosa Indica* ('monthly' rose), *Ligustrum japonicum*, and *Aucuba japonica*. At intervals along the hedges are placed examples of the trees and shrubs indigenous to or commonly grown in England. This 'arboretum' (presented by Mr Proctor) is intended to familiarise learners with the names and appearance of the common specimens which they are most likely to meet with. Every tree and shrub has a conspicuous label attached to it, bearing the English and Latin name, the order, and native country of the specimen. There is an extensive rockery on the terrace in the Garden, but it is now completely stocked with Alpine plants, and room must be found ere long for a new one. Here will be found a number of rare Pyrenean plants, obtained by purchase from Chevalier Bordère last November. The collection of saxifrages is good and flourishing. The herbaceous plants are disposed in ten plots of ground, and they are grown in narrow parallel beds, with strips of grass border between. They are of course arranged

on the natural system, a large label indicating the limits of each order, while a smaller one is placed beside every plant. Aquatic plants are grown in large pots filled with water and sunk in the ground, yet this is but a sorry substitute for pond space, and we cannot hope to make the aquatic collection either adequate or well-grown till we are able to form some pools for the special reception of this important division of plants. We have at present about 1000 to 1200 species of flowering plants, but some of the genera (and even orders) are poorly represented, while of others we have too many. But, taking into consideration that the Garden has not yet been *one year* in existence, I think we may congratulate ourselves on the progress made. I have had great assistance in the determination of plant species from my friend Mr G. C. Churchill, and both here and in the Museum I have never found lack of ready help among the boys of the College, for whose especial benefit both institutions have been formed.

When the various collections are a little better developed, I hope to issue descriptive catalogues, which will, I think, make their utility much greater. The first of the series is to form a guide to the Botanic Garden, and it will be shortly followed by others on the minerals, shells, and insects of our Museum.

It remains that I should say how urgently we require further contributions, not only of money, but of specimens. It will give me great pleasure to communicate with intending donors, and all gifts will be duly acknowledged at the Scientific Society's meetings.

The following is taken from a circular recently issued. It will give a general idea of our requirements :—

CLIFTON COLLEGE MUSEUM.

List of Desiderata.

British Fossils.—With *name* (and, if possible, locality). Those from the Palæozoic formations, and *local* specimens, specially desired.

British Rocks.—*Named*—any good typical specimens.

British Minerals.—A few good ones *only*, the collection containing already nearly 1000 specimens. The Sub-Curator (J. G. Grenfell, Esq., Clifton College) will be glad to furnish mineralogists with the names of those most needed.

British Shells.—Only the rarer ones now wanted.

British Crustacea and Echinodermata.—Any. We have very few.

British Lepidoptera.—The Sub-Curator (Rev. J. Greene, Apsley Road,

Clifton) still requires a considerable number of specimens, but the commoner ones have nearly all been supplied.

British Coleoptera.—We have a large collection already, which has not been as yet fully arranged.

British Diptera and Orthoptera, &c.—Any.

British Eggs.—Information can be had of the Sub-Curator, D. Pearce, Clifton College. Many rare eggs are needed.

British Birds.—The nests of British Birds are desirable, and a considerable number of stuffed birds.

British Mammalia.—Skins or stuffed specimens of any found wild in Britain.

British Plants.—The Herbarium now contains more than a thousand species, but good specimens of rare or local plants would be highly acceptable.

British Coins.—Any. Provincial tokens of the 17th and 18th centuries are also needed.

British Antiquities.—Celtic, Roman, or Early English remains. Many persons would probably be able to assist in the formation of this Collection, which is as yet very small.

Zoological Series.—Foreign specimens are here admissible; but, as *types* only of the principal natural divisions are required, it is desirable that the Curator should be consulted before any such specimens are forwarded.

Osteology.—The skeletons of the Perch, Frog (or Toad), Snake, Pigeon, Echidna (or Ornithorhynchus), Cat, Rat, Mole, Bat, Monkey. Skulls of the Pike, Crocodile, Tortoise, Turtle, Lizard, any large birds, any Marsupials, Sloth, Armadillo, Anteater, Dolphin, Hyrax, Lion, Tiger, Bear, Seal, Walrus, Monkeys. Separate vertebræ and other bones of Fish, Crocodile, any large birds, Carnivora, &c.

Scientific Books.—These are much required, especially such illustrated works on Natural History, Geology, and Botany as would be useful for reference.

Donations of Money for the purchase of cases and rare specimens will be of great service toward completing the Museum. Those Parents who desire to contribute a small annual sum (to be charged in the School Accounts) may obtain forms of subscription from the Treasurer of the Museum Fund (W. D. L. Macpherson, Esq., *Clifton College*).

CLIFTON COLLEGE MUSEUM AND BOTANIC GARDEN FUND, 1870–71.

RECEIPTS.

Donations and Subscriptions.

17th Sept. 1870—9th May 1871,	£265	14	6
9th May—26th July 1871,	35	10	0
26th July—31st Dec. 1871,	70	8	8
	£371	13	2

EXPENDITURE.

Museum—						
Erection of Cases,	£93	7	0			
Insect Cabinet,	12	10	0			
Purchase of Specimens and Fittings,	36	12	4			
Wages and Miscellaneous,	12	14	7			
				£155	3	11
Botanic Garden—						
Laying out Grounds,	98	1	7			
Iron and Wire Fencing,	39	7	3			
Purchase of Specimens,	8	15	1			
Wages, &c.,	17	8	5			
Miscellaneous,	3	12	2			
				167	4	6
Carriage of Specimens, Plants, and Cases,				6	14	0
Scientific Books for Library,				23	13	2
Printing Circulars and Postage,				7	14	1
Stationery and Correspondence,				2	19	8
* Balance on Hand, 31st Dec. 1871,				8	3	10
				£371	13	2

* Of this sum a small portion is owing to the Library Fund.

W. D. L. MACPHERSON,
Treasurer of the Museum and Botanical Garden Fund.

MUSEUM AND BOTANIC GARDEN COMMITTEE.

Rev. J. Percival, M.A., *Chairman.*
M. J. Barrington-Ward, B.A., *Secretary.*
W. D. L. Macpherson, *Treasurer.*
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J. F. M. H. Stone.
R. B. Don.
D. Pearce.
J. Allen.

Secretaries to the Joint Library Museum and Garden Committee—
Rev. R. B. Poole, M.A. (Library).
M. J. Barrington-Ward, B. A. (Museum and Garden).

Curator of the Museum and Botanic Garden—M. J. Barrington-Ward, B.A.

Sub-Curators—

Rev. J. Greene, M.A. (Entomology); J. G. Grenfell, B.A. (Mineralogy and Local Geology); D. Pearce (Ornithology); W. Baillie (Antiquities and Coins); J. F. M. H. Stone (Botanic Garden).

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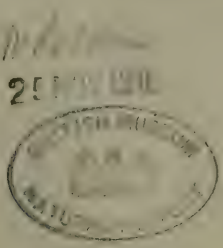

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EDINBURGH AND LONDON

TRANSACTIONS

OF

THE CLIFTON COLLEGE

Scientific Society

FOUNDED JUNE 25, 1869

"VIRESQUE ACQUIRIT EUNDO."—Virg. *Æn.* iv. 175

PART III.

CLIFTON
J. BAKER & SON, MALL PLACE
T. KERSLAKE & CO., ROYAL PROMENADE
AND AT THE SECRETARY'S OFFICE, CLIFTON COLLEGE
1872

PRICE HALF-A-CROWN

TRANSACTIONS

OF

THE CLIFTON COLLEGE SCIENTIFIC SOCIETY.

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BRITISH MUSEUM
NATURAL HISTORY

PART III.

CLIFTON
J. BAKER & SON, MALL PLACE
T. KERSLAKE & CO., ROYAL PROMENADE
AND AT THE SECRETARY'S OFFICE, CLIFTON COLLEGE
1872

PREFACE.

We trust that the Third Number of our *Transactions* will be accepted as a proof that our Scientific Society is holding its ground steadily, and doing its work well.

Our list of members is always full, and the attendance at the meetings is most satisfactory. The amount of practical work done by the members is still a weak point; but signs of improvement in this respect are not wanting, and good results are confidently expected from the new rule enforcing attendance at the Excursions. We may also hope hereafter to improve our organisation still further by carefully noting the results obtained by the Scientific Societies of other schools. An amount of experience is being accumulated which cannot fail to be of great value to us all.

The Society has suffered a great loss in the departure of its late President, Mr Barrington Ward, who spared no pains to make it efficient in every respect; and the Editors of the *Transactions* have especial reason to regret the absence of his assistance in preparing this number for the press. The Society, however, is now so firmly established, that we are enabled to look forward to our future hopefully, in the belief that the members will regard our loss as an incentive to increased energy and activity in promoting the interests of the Society. We continue to meet with extreme kindness from our neighbours and friends, to all of whom we offer our heartiest thanks.

Especially must we thank those who subscribed the funds to present us with the Bernard Collection of Fossils.

It would have cost us many years of hard work to get together such a series of local fossils as is contained in that collection. If we make good use of our opportunities, we may ultimately hope to see our collection of more than merely local importance.

The collection is especially rich in fish-teeth from the Clifton bone-bed and the lower carboniferous limestone, in remains of saurians and fish from the Aust bone-bed, in fossils from the Inferior Oolite and Lias of the valley of the Severn, and in Tertiary shells.

When they came to us the specimens were in very great disorder; considerable progress has been made in arranging them stratigraphically. Much work has to be done in naming and labelling, and the Curator will be glad of assistance in doing this.

Our special thanks are also due to the Rev. J. Greene, who has completed his task of arranging our Lepidoptera, and filling our drawers with specimens from his own cabinet.

Also to Mr S. Barton, who is arranging our Coleoptera.

Lastly, to Mr Lant Carpenter for his interesting Lecture on Deep-sea Dredging, and to Messrs Jose, Fox, and other old Cliftonians, who have in various ways been of much assistance to us.

J. G. G.
C. C. S.
H. W.

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Zoology, *Botany* ...D. Pearce.
Entomology.....W. Claxton.
Geology.....J. G. Grenfell, B.A.
Archæology.....J. E. Jose.
Chemistry.....P. R. Ogle.
Physics.. .....W. A. Smith.

RULES.

I.—That this Society be called the 'CLIFTON COLLEGE SCIENTIFIC SOCIETY.'

Constitution.

II.—That the Society consist of Ordinary, Corresponding, and Honorary Members.

Officers.

III.—That the Officers of the Society consist of a President, Secretary, Treasurer, and five Members of Committee, to be elected from and by Members of the Society, with the exception of the Secretary, who shall be chosen by the Committee from their own number. All Officers, excepting the President, to be elected terminally.

Management.

IV.—That the affairs of the Society shall be conducted by the above Officers.

Secretary.

V.—That the duties of the Secretary be, to keep a list of all the Members of the Society, and of all former Members and Benefactors, who may wish to receive the Transactions of the Society; to give notice of meetings, and to keep a detailed report of the proceedings, as well as lists of Members and Visitors present at each meeting. In the absence of the Secretary, the President may appoint any Member of the Committee to take minutes of the proceedings.

Treasurer.

VI.—That the duties of the Treasurer be, to collect all sums of money due to the Society, to receive all donations of money, and to disburse all sums of money payable by the Society out of the funds intrusted to him.

That the Treasurer furnish terminally a detailed account of the receipts and disbursements, to be audited by the Committee.

Members.

VII.—That the number of Members be seventy, of whom ten shall be elected from the Junior School.

That Honorary Members be elected by the Committee, for two years only; but any Honorary Member re-elected after that period, be not required to pay any further subscription.

That Honorary Members, on the payment of the single sum of one guinea, or the annual sum of five shillings, shall receive the Transactions, post free.

That Corresponding Members be elected by the Society for five years; but that a Corresponding Member, on signifying to the Secretary in writing his desire to remain on the Society's books at the termination of that period, be allowed to do so.

That Ordinary Members be elected by the Committee.

That, on election, every Member of the Society shall sign his name in a Register (to be kept by the Secretary).

That a subscription be payable terminally by all Ordinary Members (the amount to be fixed by the Committee), but in no case to exceed Two Shillings and Sixpence for the Upper, and Two Shillings for the Junior School.

That Honorary Members residing at the College shall have all the privileges of Ordinary Members.

That all subscriptions must be paid between the first and second meetings of the term, and that any Member retiring from the Society be required to pay all subscriptions due.

That, under penalty of expulsion from the Society, all Ordinary Members be required to attend two-thirds of the meetings in each term, except for reasons deemed sufficient by the President.

That Corresponding Members shall have the privilege of taking part in the proceedings of all meetings that they may attend, but shall not be liable to any subscription.

Sections.

VIII.—That Sections be formed for the more accurate study of the different branches of science, and that the Directors of these Sections be chosen terminally by the Society.

That the Sections shall hold meetings as often as may seem fit to their respective Directors, at which any Members of the College, with the sanction of the Director, may attend.

That the Directors of the different Sections be invited to communicate to the Society any matters of interest which may have come before them, and that such communications be made at the commencement of each public meeting, at least one day's notice having been given to the Secretary.

That reports of the work done in each Section shall be handed by the Directors to the President before the final meeting of every term.

That the President and Secretary be *ex officio* Members of every Section, and shall receive notice of all sectional meetings.

That not more than ten Members be permitted to join any one Section.

That all elections in each of the Sections be vested in its Director, who may, at his discretion, remove any Member from it, subject only to the approval of the President.

That there shall be seven Sections: BOTANY, ZOOLOGY, CHEMISTRY, PHYSICS, ENTOMOLOGY, GEOLOGY, and ARCHÆOLOGY.

Meetings.

IX.—That ordinary Meetings of the Society be held at least once a fortnight during term, but that the President be empowered to call extraordinary Meetings and to postpone the regular Meetings.

That fifteen Members shall form a Quorum.

That the order of business at each Meeting shall be arranged by the President.

That Members be requested to bring for exhibition at the Meetings of the Society, specimens of Natural History and illustrations of Natural and Physical Science in general.

That Members be invited, when they may have it in their power, to present donations and specimens to the College Museum, such donations to be acknowledged at the Meetings, and in the Society's Transactions.

That in all cases of equality in voting, the President shall have a casting vote.

New Rules.

X.—That any Member of the Society have power to propose any new rule, or any alteration in an old one, provided the motion be seconded by another Member, and that notice of at least one week be given to the Secretary.

Excursions.

XI.—That two Excursions be made every three weeks for the purpose of studying Natural History. That Members of the College, not in the Society, be allowed to attend on obtaining permission from the President; the number thus admitted not to exceed eight.

That all Members of the Society below the sixth form, who have not otherwise taken an active part in the business of the Society, be obliged to attend two Excursions in every term, under penalty of surrendering their places in the Society to qualified candidates.

TRANSACTIONS

OF THE

CLIFTON COLLEGE SCIENTIFIC SOCIETY.

THIRD TERM, 1871.

MEETING, September 29, 1871.

The President in the Chair.

The President announced that the Committee had elected J. Robinson, Esq., F.C.S., an Honorary Member. He also stated that the subscriptions for the term were two shillings and sixpence for the Upper, and two shillings for the Junior School. The business of the evening was the election of Directors of Sections.

J. G. Grenfell, Esq., was elected Director of the Geology Section, Rev. J. Greene of the Entomology, J. C. Prinsep of the Archæology, J. F. M. H. Stone of the Zoology, J. Robinson, Esq., of the Chemistry. For the Physics Section, W. A. Smith was elected from four candidates. F. T. Saunders was elected Director of the Botany Section, there being also four candidates.

The President announced the following contributions to the Museum:—A Stuffed Squirrel and Magpie, by A. H. Heath; a Box of River Shells, by Davis; a beautiful specimen of Petrified Wood from Trinidad, by J. A. Gibbons; Mud from bottom of the Atlantic, and a small collection of Tin-ores from Cornwall, by Mr Ward; Two Tusks of the Boar and two Tiger's Claws from India, by General Younghusband; some Shells and Fossils, by R.

Richardson; Bird Eggs, by Niblett. T. L. Jenkins had been announced to give a paper on 'The Natural History of Tenby,' but owing to the pressure of other business it was postponed.

The following were elected members of the Society:—G. E. Locke, J. Gibbons, J. J. Hewson, G. L. Lestrange, L. G. Bonham-Carter, J. Bell, G. Maw, F. Fuller, P. A. Ogilvie, R. Richardson, H. Fowler, W. W. Clark, W. H. Druitt, A. Evans, E. J. Crosse, W. C. Saville, J. D. B. Forbes, R. P. Sumner, A. E. Darley, W. A. Darling.

MEETING, October 6, 1871.

A special meeting was held on 6th October, to elect a Director for the Botany Section, in the place of F. T. Saunders, who had resigned that office. G. Dakyns was elected.

MEETING, October 27, 1871.

The President in the Chair.

The first regular meeting for the term was held on 27th October. There were forty-three members and visitors present.

The following donations to the Museum were announced by the President:—A Box of British Eggs, by Mrs Battersby; Iron-ores from South Wales, by A. Batchelor; a large quantity of Foreign Shells, and some Minerals, by the Misses Shakspere; a Piece of Agate, and other Minerals, by J. Gibbons; some fine specimens of Stalactitic Iron, and Iron in the various stages of its Manufacture, from the Forest of Dean, by H. J. Greenham, Esq.; a few Coins, by F. Wedderburn and Mrs Buchanan; Minerals, by Lukis; Fossils, by J. G. Grenfell, Esq., and the Geology Section.

The President announced that the Committee had elected Rev. Charles Kingsley, Canon of Chester, an Honorary Member.

The President then read the following address:—

Gentlemen,—It has been my custom, since you honoured me by electing me President of this Society, to say a few words at the beginning of each term with reference to things past, present, and future in our short history. And on being asked by the Committee a few days ago to open the session in this way, I readily consented; for it is always a pleasant matter to me to ad-

dress such an association as this is, young, vigorous, and healthy, possessing in its anticipations and prospects what it necessarily lacks in traditions and antiquity. I think I can with truth say that there seems to be an amount of reality in the life of this Society, still in its infancy, which accords thoroughly with everything done at the Institution of which it forms so small a part.

There are few occasions on which a non-clerical master can have the opportunity for what Mr Huxley calls a 'lay-sermon,' and yet there are matters of real consequence which it is one's duty to inculcate, but which would be somewhat incongruous among the sacred teachings of the pulpit. To-night, therefore, if you allow me, I would urge upon you the importance of observing the good old proverb, 'Make hay while the sun shines.' Time flies very quickly here, as elsewhere; and in a short time your places in the busy world of school will be taken by others, who must in their turn make room for succeeding generations. The two years of our Society's existence have been sufficient to largely re-people the College. There are few here now who remember that meeting on an evening in June 1869, when a few boys assembled to take into consideration the question of forming a Scientific Society. There is not one boy here who remembers the opening of the College. And so it will come about by and by, when school-days are with you a thing of the past, that you will return to that scene hallowed by the memories of the happiest time of your life, and find yourself forgotten where you remember everything. I know well, and so does every one who has revisited his old school some time after leaving it, how melancholy and strange one feels when he paces once more the old familiar cloister and playground, and enters again those class-rooms which bring up to his recollection so many, many incidents of bygone years: pleasant they may have been, or the reverse, yet they are now all alike blended and toned down by the potent hand of memory, which makes things that were once bitter sweet, and renders the dim vista of the past delightful in every feature.

If, then, our days at school are few and fleeting, we ought certainly to make the most of them, and, whether we work or play, do everything thoroughly.

I hope you will take in good part what I have said about earnestness, and apply it to yourselves as members of this Society. I will not assume the laudatory tone, and do nothing but congratulate you upon what really appears to be honest and well-founded success. Others may do so, and in the outer world the Scientific Society is already widely, and, I think, favourably known. Here it will be more profitable, if less pleasant, to tell you in what points it is weakest, and ask you to join with me in

bringing about an improvement. I feel sure you will give me credit for the heartiest interest in the welfare of the Society, and that interest would not be a thorough one if I were to gloss over our defects, and make people think that we had already attained to the highest perfection.

Now, first and foremost, I will tell you honestly that I do not believe one half of us here value our privileges, and properly estimate our responsibilities as members. There are many fellows who think that they have done ample when they have attended three-fourths of the meetings, listened attentively to the interesting papers, and sat quietly during the dull ones. They are very vigorous with their applause; but if we go and ask them to prepare a lecture of some kind, we meet with a ready refusal,—"No, thank you; I don't know what to write about; I'd rather not." I ask you, is that fair? You call yourselves members of the Scientific Society, and yet you leave all the duties to other people, and take no more real part in its working than those sham armies and villagers play whose presence is needed for filling up the dramatic stage and giving an air of reality to the entertainment. With us the minority, fortunately, is a zealous one, and I thank these working members heartily for their zeal. On them rests all the onus of the Society, and but for them it would long ago have dwindled into insignificance. But I say emphatically, and I say it advisedly, that it is not fair or right for the idler and the lounger to continue in our ranks. I would rather see the Society cut down to half its numbers than filled by mere puppets, whose concern for its welfare was expressed by an occasional hour's attendance on Friday nights, and nothing more. There is far more to be done than this, and I will tell you how it may be done.

You will remember how I said, a few moments ago, that among the innumerable diversities of natural gift and bent, it was impossible to expect all people to follow the same pursuits with equal energy. And so is it with regard to the affairs of the Scientific Society. There will always, I hope, be a few members ready, willing, and able to take the lead in its management, and a few who will give to the natural sciences the same time and attention that others expend on classics or mathematics, or even the no less important games. But of the great majority of the Society,—its rank and file, so to speak,—this is not to be expected. Yet all may do something, while but the few do much; and I think I can show you what I mean. We have a great many various studies and pursuits fostered, in name at least, by the Clifton College Scientific Society. Excepting only the British Association itself, I know of no other whose range is so wide. Botany, Zoology, and Entomology; Geology, Chemistry, and Physics; Antiquities;

all are recognised here; and each one of these sciences might be again connected with sundry others which could not be said to be foreign to our scope and aims. What an immense field is this for the intellect to rove over! Surely you could not find any sensible boy who does not take an interest in some one of these many means of delight! I know of those here who are fond of bringing together the eggs of our British birds, sparing no pains and running any risk to obtain a coveted specimen. I know of those whose tastes lead them to observe and appreciate the resemblances and differences between the many forms of beauty in which plant life appears; and of others who are enthusiastic lovers of insects. Few boys, again, can help taking interest in chemical and physical experiments; and though no doubt many witness them simply as they would a firework exhibition, and give their loudest applause at the most striking effect and the loudest report, there is still something so attractive in investigation and analysis, that few can begin them without being allured into making them a subject of real and delightful study. What charms have the wonders of geology for the observant eye! and where are better opportunities afforded for tracing the silent record of the rocks than at Clifton, with its magnificent river section, and beds teeming with fossils? Lastly, I feel sure that, among the many students of history, ancient and modern, that a great school like this always possesses, a large number will be found to feel an interest in those relics of the works of man in bygone ages which the hand of time has still spared to us; who will, in fact, take pleasure in the study of historical architecture and numismatics, and will see in each old carved stone, in each half-effaced coin, the imprint of a hand now mouldering in its kindred dust, and the evidence of the skill of man as well as the certainty of his dissolution.

Amongst this large range of pursuits some one, at least, is sure to commend itself to every boy in this room, and here he can, if he chooses, pursue his favourite study with advantage to himself and his fellow-members. We have, as you are aware, founded seven Sections in the Society, for the more careful study of Botany, Zoology, Geology, Entomology, Physics, Chemistry, and Antiquities. You will be called on this evening to say whether or not you are disposed to enter one of these Sections; and I hope that those who want to do real work as members of a scientific body will not only enrol their names, but exercise their industry and ingenuity in advancing the cause of the particular branch which they may favour. The Directors of the Sections have a weighty responsibility on them for the duties they have undertaken. Those of them who are as yet but tyros (are we not in science all

but learners?) must bear in mind that the Society expects them to give more than ordinary attention to their own science, and to leave no stone unturned by which good results may be obtained. Better have no Sections at all than have them mere listless shams, than mere *vox et præterea nihil*. I do from my heart wish to see this Society a real honest one, heartily and zealously pursuing its stated aims, and doing some little good in the world. I cannot but think that there are many members willing to exert themselves, if they only knew how to do it, but who, from a distrust in their own powers, and a bashfulness only natural in the young and inexperienced, shrink from coming forward as readers of papers, from speaking at the meetings, or, in fact, taking any active part in the Society's operations, unless regular attendance and careful listening be considered activity. My good fellows, you only need encouragement, and that encouragement the senior and more forward members ought to give you. For my own part, I shall be indeed happy to tell you anything I can, or suggest to you various ways in which you may contribute your mite to the general welfare of the Society. You might try to help us with the Museum, asking your friends for contributions to it, and looking out for suitable specimens yourselves. Indeed I always value the boys' own contributions more than any others, for I think such gifts tend to make the Museum fulfil one of its greatest objects. You might also bring interesting objects to exhibit at the Society's meetings, and you need not be the least ashamed to read a short paper, even one of five minutes. We will give you a patient hearing, I assure you. If you don't know subjects, I can suggest them to you: if you have not good books of reference, or proper means of illustration, I think I can often help you there as well. And when I speak for myself here, there are various other members, both masters and boys, who will just as readily assist you. There is plenty of work for us all, and the blame will lie at our own door if we do not make the Clifton College Scientific Society fulfil the wishes of those who founded it, and those who have directed it in its early days, reaping a rich harvest of pleasure and improvement for ourselves, and sowing seed which will blossom and bear fruit for the many generations that are to come.

In conclusion, gentlemen, I thank you for the patient hearing you have given me during a long speech. My subject is perhaps trite and commonplace, but it is well to be reminded occasionally of our duty; and I sincerely trust that my remarks may stir up in many here to-night a little more enthusiasm and a little more zeal than are at present exhibited. I have said nothing till now of some pleasant points about our Society that are very encouraging, and form the silver-lining to the cloud, if cloud there be

any. Our list of members is quite full. We have a truly useful and a highly valued one in Canon Kingsley. I had the pleasure of showing the latter gentleman, a few days ago, that Museum and Garden of which he may well be deemed the original suggester, and I can hardly tell you how much I was gratified by the way in which he spoke of the success of both projects. It did much to recompense me for many an hour's labour, and has stimulated me to greater energy for the future. But though the Museum is rapidly filling, and the Garden is stocked in such a way as to make it excel any school-garden in England, I do not think that they are perhaps known or valued as they should be. I fear too many consider the Botanic Garden as very pretty to look at, but not much use in other ways. They know not how rich it is already in its possessions, nor how botanists from all parts daily lend me a helping hand in adding to it whatever they have at their disposal. I could tell of plants expected from Kew, from Liverpool, Cambridge, Oxford, Hull, and Broseley; of those already come from London, Dublin, Glasgow, and Bilton; nay, more, within the last few days I have received and planted a large series of exceedingly rare and interesting forms from the far-distant Pyrenees, sent to me by that illustrious botanist Chevalier Bordère;—all these things will very soon make our Garden the admiration of botanists; and though the growth of the Museum must of necessity be slower, it, too, makes rapid strides in an onward direction. Mr William Sanders' fine collection of 800 minerals has recently come into our possession, thanks to his own liberal offer, and the assistance of the Rev. James Heyworth; while it is only within the last few days that a generous donation from the relative of a member of our Society enabled us to order a complete series of polished specimens to illustrate the rocks of Clifton. I mention all these details here that you may see what real progress is being made.

During the present term we expect to be favoured with lectures from Mr Lant Carpenter and from other friends. A considerable number of members have promised to read papers. The new number of *Transactions* will be in your hands next month, and I am anxious now to see the Sections well at work, and every member doing his best to make this one of the most successful sessions which the Society has yet seen.

T. L. JENKINS next read the following paper on

THE NATURAL HISTORY OF TENBY.

Before giving a description of the Natural History of Tenby, I will briefly show you what was the state of Tenby in early times,

and what it is now. The town of Tenby is of early origin, but of its history previous to its occupation by the Flemings, there is nothing known. Tales of Danish pirates, who once visited the coast, are authenticated by history, and remains of camps, said to be Danish, may be seen along the shores. Tenby was one of the first colonies founded by the Flemings in Pembrokeshire, in the year 1108, when the Netherlands became for the greater part inundated; and the inhabitants consequently obliged to seek their fortunes in other countries. Fresh bodies of Flemings continued to pass over from time to time in such numbers, that at length they gained a firm footing in Wales, despite all the attempts of the natives to dislodge them. They then proceeded to erect numerous fortifications of great strength as a means of defence. Tenby was even at this early date frequented by the Earls of Pembroke, who granted numerous charters and privileges to the town. The next occurrence worthy of note took place in 1473, when Jasper Earl of Pembroke, being besieged in his castle, fled from Pembroke with his youthful nephew, Henry Earl of Richmond (afterwards Henry VII.), to Tenby, and thence to Brittany. In the reign of Elizabeth, at the time of the Armada, the defences of Tenby were strengthened. During the civil wars Tenby was garrisoned for the king, and in February 1643, the Parliament fleet arrived at Milford. On the 6th of March, the land forces proceeded against the town, when, after sustaining a siege of ten days, it surrendered. After this we do not hear of Tenby as a place of military strength, and it seems to have been merely visited for its fisheries, which had always been celebrated, its name, *Dynbych y Pisgod*, signifying the place or precipice of fishes. At the end of the last century it had dwindled down to a mere fishing-village, but it has since gradually risen, until it is now become a fashionable and favourite watering-place.

The town of Tenby is built on a rocky peninsula, rising nearly 100 feet above the level of the sea, being 1100 yards long by 650 broad. Tenby stands on the southern edge of the Pembrokeshire coal-field, upon the lower shale-beds of the mountain limestone, here much broken in irregular lines. The principal street extends the entire length of the town. The part called High Street, above the North Sands, is for some distance carried along the edge of the cliff; passing the church, the same continues, under the name of St Julian Street, to the South Sands.

At low water the beach extends for two miles to a promontory called *Giltar* Point. On reaching the sand, the little island of *St Catherine's Rock* stands before you. On the summit of the rock are the remains of a building, formerly a chapel, dedicated to St Catherine. The view from St Catherine's is extensive towards

the west; first comes the island of *Caldy*, and at low water a ridge of rocks can be seen extending from Caldy Point, to the opposite point of St Margaret's Island. At the South Sand's gate or archway commence the ruined walls and towers of the castle. A low irregular wall extends round the Castle Hill on the verge of its cliff, while the hill itself, gradually rising, is surmounted by a keep. The crescent sweep of the north side of the town, with the cemetery chapel, is seen beyond. The steep North Cliffs rise from the beach below, and terminate in an irregularly formed projection called *Monkstone*. Beyond this point is the bay of Saundersfoot with Amroth Castle.

Tenby is a market-town and municipal borough of great antiquity, and, conjointly with Pembroke, Milford, and Wiston, returns a member to Parliament.

Geology.—To the north of the town lie the coal measures, which yield anthracite coal. The so-called beetlestones (found on the north shore towards Saundersfoot) are nodules of clay-ironstone, the centre or nucleus of which appears to have been sometimes animal, sometimes vegetable. The mountain limestone lies to the south of the town. The old red sandstone commences at Skrinkle Bay; but few characteristic fossils of this formation have as yet been discovered in Pembrokeshire. The Silurian formation succeeds in due order, so remarkable for that strange extinct crustacean the *Trilobite*. The tails of the two species of these occurring here seem to identify them with the lower beds. The coal-basin of Pembrokeshire extends from Saundersfoot westward to Milford Haven. The coal of this district is all anthracite or stone-coal; while the veins of the clay lying above and beneath the coal are full of the roots and stems of the *stigmaria* and other plants.

The remains of a submerged forest may be seen on the shore near Amroth at low spring-tides; the wood is nearly all decayed, and on being touched crumbles to pieces. Tradition makes mention of a sunken tract of land called *the Lowland Hundred*, (*Cantrev y Gwaelod*), said to have been situated off the northern coast of the county, and to have occupied a considerable portion of what is now Cardigan Bay. This tract of country was probably lost by the subsidence of the land, and not, as might be conjectured, by neglecting the sluices. The coast near Amroth and Saundersfoot seems to have undergone three distinct changes at three different periods, for by digging at low water below the remains of the forest then exposed, a sea-beach is found. From this we may infer that at one period the beach now deeply submerged must have been level with the sea; at a second period this beach must have been elevated, whilst a third shows it again submerged.

Conchology.—Tenby has long been the favourite resort of Conchologists, as a locality abounding in rare shells; but although after stormy weather many shells may be found towards Giltar Point, a good collection cannot well be formed without dredging. Remains of shells are occasionally gathered in the rocks on the South Sands; and at Giltar Cliff, opposite St Margaret's Island, madrepore occurs. Crystals and spars are found on this coast, and also near Saundersfoot. The phosphorescent luminosity of the sea-coast round Tenby often presents a most wonderful appearance.

Ferns are peculiarly abundant and luxuriant, among which the marsh fern (*Lastrea thelypteris*), the sweet fern (*Lastrea oreopteris*), the male fern (*Lastrea filix mas*), occur in great plenty; other ferns are the hay-scented fern (*Lastrea æmula*), the brittle bladder-fern (*Cystopteris fragilis*), the lady fern (*Athyrium filix fœmina*), the common prickly fern (*Polystichum aculeatum*), the angular leaved prickly fern (*Polystichum angulare*), the black spleenwort (*Asplenium adiantum nigrum*), the wall rue spleenwort (*Asplenium ruta muraria*), the common wall spleenwort (*Asplenium trichomanes*), the hart's-tongue spleenwort (*Scolopendrium vulgare*), the scaly spleenwort (*Ceterach officinarum*), the hard fern (*Blechnum boreale*), the flowering fern (*Osmunda regalis*), the common adder's tongue (*Ophioglossum vulgatum*), and the common brake (*Pteris aquilina*).

The epithet *Dynbych y Pisgod*—the place of fishes—was formerly with great fitness applied to Tenby, and though now obsolete, still remains appropriate, as numerous fishing-smacks are always to be seen in the bay. The best fish taken are the salmon, sewin, red and grey mullet, mackerel, turbot, soles, whiting, haddock, cod, and herrings. The oysters gathered at Tenby are very superior.

Ornithology.—There are three different species of sea-birds found in the neighbourhood of Tenby, viz., the guillemot, razorbill, and puffin, which frequent the Stack Rocks in thousands; they are also found in great numbers at intervals from Stackpore Head to Limney Head, and upon the west side of Caldy. The guillemot is locally named the *eligug*. It is not easy to distinguish between this bird and the razorbill. The beak is strong, sharp, and compressed; the head, back, and tail are sooty black; the breast, vent, and undertail coverts white, and the legs round but slender. The egg is peculiarly large in proportion to the bird's size: an egg has been taken as early as the 18th of May. The great mass of birds begin to migrate about the 1st of August, and by the 5th scarcely one is to be seen on the coast. The habits of the razorbill very closely resemble those of the guillemot, but

they breed at greater distances from each other, and not in masses, as the latter bird. Its bill is sharp and narrow, like a razor, and hence its name. The puffin has a curious habit of dislodging rabbits from their holes where they hatch their eggs. The beak is peculiarly broad and compressed, having at a distance the appearance of a parrot's, the feet, being more forward than those of the guillemot and razorbill, enable it to walk, whereas the others waddle. The following birds are common in the neighbourhood of Tenby :—viz. missel thrush, jackdaw, fieldfare, magpie, wren, blackbird, song-thrush, redbreast, redstart, stonechat, sedge-warbler, tree pipit, swallow, martin, sand-martin, wood-pigeon, partridge, moorhen, dabchick, skylark, chaffinch, greenfinch, linnet, starling, gulls, cormorant, and peregrine falcon.

The county and coast of Pembrokeshire is celebrated for an excellent breed of falcons, of which we have the following notice in "Fuller's Worthies:"—"King Henry II. passing hence into Ireland, cast off a Norway goshawk at one of these, but the goshawk, taken at the source by the falcon, soon fell down at the king's feet, which in this rumage made him yearly afterwards send hither for eyesses. These hawks' eries are found in the rocks of this shire."

MEETING, November 3, 1871.

The President in the Chair.

The second meeting for the term was held on 3d November. There were eighty-five members and visitors present.

The following donations to the Museum and Botanic Garden were announced :—Skin of Snake from California, by Mrs Ward, Belfast ; Tiger's Teeth, by C. S. Penney, O. C. ; Skin of Indian Snake, by A. Younghusband ; a large Series of Fossils, by S. Worsley, Esq. ; over a hundred Herbaceous Plants, from the Botanic Garden, Hull, by J. Niven, Esq. ; fifty Herbaceous Plants, by Rev. H. N. Ellacombe ; Lace Bark, by S. Douglas ; some Coins, by W. E. Hill.

A most interesting lecture on "The Magic Lantern as applied to Scientific Teaching," was delivered by Rev. Walter J. Whiting. The subject throughout was illustrated by slides shown in the lecturer's lantern. At the close, a vote of thanks to Mr Whiting was proposed by T. H. Warren, seconded by J. F. M. H. Stone, and unanimously carried.

MEETING, November 17, 1871.

The President in the Chair.

The third meeting for the term was held on 17th November. Fifty-three members and visitors were present.

Donations to Museum acknowledged:—Two Birds' Nests, by C. Henderson, O.C.; Dried Plant (*Dianthus deltoides*), by Miss E. Marriott; a Scorpion in glass shade, by J. E. Jose, O.C.; young stuffed Turtle, and piece of Heart Oak, by W. Webb, Esq.; *Quarterly Journal of Science*, Parts 31 and 32, *Geological Magazine*, No. 89, and "Handbook of Cornish Mineralogy," by F. F. Tuckett, Esq.; two pieces of Maundy Money, by W. F. Trimnell, Esq.; some Tin and Copper Ores, by H. Grylls; some Fossils, by J. G. Grenfell, Esq., and the Geological Section.

J. I. Fox, O.C., next read the following paper on—

BRISTOL CATHEDRAL.

About the middle of the twelfth century there resided at Bristol, in Baldwin Street, a merchant of great wealth and enterprise, Robert Fitzharding by name. His father was Harding, son of the king of Denmark, and is said to have come over to England in the train of William the Conqueror. This man entertained Dermot MacMurrough, the exiled king of Leinster, when he came to solicit help from Henry II. He received, for his fidelity to the Empress Maude, the lordship of Berkeley, which had been forfeited by his kinsman, Roger de Berkeley, who had followed the fortunes of Stephen, and from him are descended the present Earls of Berkeley. In 1142 he founded a monastery, which was completed in 1148, into which he himself retired towards the close of his life. At the beginning of the fourteenth century it was considered necessary to rebuild the monastery, for what reason we do not know, but judging from the strength of what now remains, it is hardly probable that it was decay. All that is left of the original structure is the vestibule, chapter-house, and the arches in upper and lower College Green.

The establishment of the abbey consisted of an abbot, prior, subprior, and fourteen friars. The abbey was dedicated to St Augustine, and was also called "The Monastery of the Black Regular Canons of the Order of Saint Victor." The rebuilding of the abbey was commenced in 1306, by Abbot Knowle, and was not finished until 1363. For the purpose of obtaining money, Pope Urban II. granted a bull giving forty days' pardon and

release from penance to any one who should, on festival days, hear mass, or say kneeling three ave-Marias in this church, or who should give any vestments, ornament, gold, silver, books, chalices, or any aids of charity to the repair of the said church, or should pray for the life and good estate of the noble Maurice, Lord Berkeley, his wife and children, or for any being in purgatory. When Henry VIII., having quarrelled with the Pope, ordered the dissolution of the monasteries, this, with the three others in Bristol, was to have been demolished. But Henry, having determined to form Bristol into a bishopric, selected the Abbey of St Augustine as cathedral, and dedicated it to the Holy and undivided Trinity. He appointed six canons, six minor canons, six lay-clerks, and six choristers. The numbers, however, have since then been changed. In 1542, Paul Bush was appointed first bishop, but was afterwards removed by Mary, because he had married. In 1836, the dioceses of Gloucester and Bristol were united. The most renowned of the Bristol bishops was Bishop Butler, author of the "Analogy," who was afterwards translated to the see of Durham.

I will now proceed to describe the architecture of the cathedral and the buildings attached to it. Let us begin with those which were first erected. The arch of St Augustine, which formed the gateway of the abbey, is Norman, and is richly ornamented with the zigzag mouldings and scolloped capital peculiar to that style. So perfect are the mouldings, which have stood the wear and tear of centuries, that many have supposed that it was rebuilt. But this is not likely, as the fifteenth century architect who erected the upper part would not have understood how to build it in the Norman style. The archway in Lower College Green, which leads to the abbot's house, is also Norman, as is the chapter-house, with its arches beautifully enriched with cable and zigzag mouldings. It contains three windows of stained glass, which, throwing a softened light over the apartment, add much to its beauty. These buildings were erected between 1142 and 1148. The older Lady Chapel, which was built between 1216 and 1234, is considered a good specimen of the early English style. The spandrils of the arcade in the south wall are ornamented with sculpture of a very grotesque description. This chapel is on the left hand as you enter the cathedral. The other Lady Chapel, which now forms the chancel, was built at the most perfect period of English architecture, between 1306 and 1363. It is in the decorated style, and was built by Abbot Knowle, whose tomb is placed next to the altar, and opposite are the sedilia. The other monuments are those of Abbots Newbury and Newland. These monuments are noticeable for their canopies, which are ornamented with richly-

carved cusps and foliages, and are of very rare occurrence. But by far the most remarkable feature of the chancel is the magnificent east window (which is considered one of the finest in England), with the beautiful tracery of its transome and the deep red colour of the ruby glass, for which the Middle Ages were so celebrated. The fine combination of colour should also be noticed especially by us Englishmen, who are not conspicuous for taste in such matters. The upper part of the window contains the arms of various benefactors of the church. In the centre are figured Christ and the Virgin Mary, with several of the Jewish kings, and on each side are six of the prophets. There are four other windows which have recently been restored. Beneath the east window is the gilded and coloured diaper-work of the reredos. This diaper-work is copied from coloured silks which were brought from the East, and were often used as hangings for the walls. Above this are the arms of the Plantagenet, Berkeley, and De Clare. The arms of Berkeley, which are found all over the cathedral, are gules a chevron between ten crosses pattée argent. The choir is the largest in England, but this is because the altar-screen, which stood three bays from the east window, was removed. This is rendered apparent by the difference in mouldings of the roof. The choir and aisles are of the same height, which does not occur in any similar building in England. This adds greatly to their effect. To counteract the thrust of the arches of the choir, it was necessary to construct horizontal buttresses or beams in the interior, and also strong buttresses and flying buttresses on the outside. There is, therefore, no clerestory, which detracts much from the appearance of the exterior. At the east end of each aisle are enamelled windows, which Nell Gwynne is said to have presented to the cathedral. There are several tombs of the lords of Berkeley, one of whom was a knight-templar, as is shown by his crossed legs. On the south side is the Newton Chapel, which contains the monument of the Newtons of Barr's Court. On the west wall of this chapel is a beautiful monument, by Westmacott, in memory of Charlotte Stanhope, and one of Bishop Grey, by Bailey, who has also produced two in the north aisle, one a bust of Southey, the other, which is a veiled figure, in memory of a Mrs Middleton. Some of the monuments have very beautiful verses on them, which are well worth studying. There is some very amusing carving on the *miserere* stalls. In one, a fox is holding forth to some geese from the pulpit. In another, an old gentleman, mounted on a sow, is having a tilting-match with an old lady mounted on a turkey-cock; they are both armed with brooms, and the old lady has wisely preserved a second in reserve behind her.

The transepts were built between 1463 and 1515, and the tower between 1428 and 1461. It is in the perpendicular style, and is 127 feet high. The greater part of this church was built in the decorated style, which is considered the most beautiful of all the types of Gothic architecture, approaching, as it does, nearer to nature than any other. Its grandeur can best be appreciated when the glare of daylight has given place to the dusky twilight of evening, which gives to the vaulted roof overhead an appearance of greater height than it really possesses, and that aspect of dimness and gloom which exerts so powerful an influence of awe and mystery over the human mind.

W. J. P. WOOD next read the following on—

GOÎTRE AND CRETINISM.

The diseases about which I am about to speak to-night are hardly known in England; perhaps then it will not be amiss to say a few words on the subject of the diseases themselves, and the appearances which they present.

Goître is a swelling of the thyroid gland, or the parts adjoining it, and presents the appearance of a lump of flesh attached to the neck, immediately below the chin. This swelling increases with the growth of the individual, until in some cases it attains an enormous size. Such, however, is not a universal fact, for in the great majority of cases, the lump does not appear to exceed in size a small apple. I was in Switzerland myself last summer, and saw several of these goîtres. I took notes of the facts which I observed, for the appearance was quite new to me, and I had never heard of the complaint before. The goître does not appear to be in every case *immediately* under the chin, but rather on one side; sometimes I have noticed it on the right, and sometimes on the left. With regard to the size of the swelling, it seems to vary much in different people; in boys it is very small, and not likely to be noticed except in exceptional cases. On the other hand, I have seen a man wheeling a barrow with a leather strap under his swelling; and this was not so surprising, for as he came nearer, what I had before taken to be something tied round his neck, I now saw to be a huge tumour, like a well-blown bladder, and nearly, if not quite, twice as big as his own head! This was the largest one that I ever observed; but I have seen others at least as big as a moderately sized melon. Other instances have been recorded in which the tumour has been known to grow to such a size, that its victim could no longer support his burden, but was compelled to creep on all-fours along the ground. Such an immense swelling of the organs in immediate connection with the

windpipe, must, one would have thought, produce the greatest difficulty and irregularity in breathing. Indeed, one great work on Anatomy states that it does so; but I questioned several Swiss on the subject, and they said that they found not even any inconvenience arising from it; so that they were able to run and jump without losing their breath sooner than other men. Perhaps in their case this was because their tumours were comparatively small; that is, about the size of a billiard-ball. I may here remark that the goître is not usually looked upon as a deformity; it is much too common for that; nay, in some cases the women who have no swelling are laughed at, and called "goose-necked." Attempts have been made by medical men to remove this unsightly swelling, but in no case has the attempt succeeded, except by one application, namely, that of iodine. Iodine applied externally has been found very useful, but its action is yet unknown, nor is it likely that it will be understood until more is discovered as to the sources of the goître itself.

Cretinism is a disease probably originating in the same cause as goître, but its effects are widely different. The goître seems to be of but little importance to the afflicted; for provided that the swelling is not large, it does not come in his way; it seems not to interfere perceptibly with his breathing, neither does it exercise any prejudicial effect on his spirits; for he seems as happy and contented as if he had no huge tumour to render him a repulsive object to the eyes of his fellow-creatures. Cretinism, on the other hand, is a disease afflicting the mind. The cretin is an idiot, and in many cases so little reason has he left, that he is unable to find his way home, even when only a few feet from his own door! Most of the cretins have goîtres also; but this may only arise from the fact that wherever cretinism prevails, goître is also found. I have seen several cretins myself without any perceptible increase in the size of the neck, so that though it is often the case that cretinism is accompanied by goître, yet it by no means invariably occurs. They both begin to develop themselves about the age of puberty; but if the children are then removed, when goître is first beginning to be developed, they often get the better of it.

The cretin has his mad fits, like other madmen, being much worse at some times than others. His head grows disproportionately large; his words become thick, until his speech entirely deserts him; and his limbs become stunted and deformed. Thus cretinism is a far more serious malady than goître, afflicting both mind and body.

Cretins seem to be extremely fond of sunshine; they will bask in it for hours together, apparently wanting nothing. They are

perfectly harmless, and do not show any tendency either to do harm to others, or to injure themselves. Notwithstanding their dumbness, they will assail the unfortunate traveller with a continual chattering of inarticulate sounds, every now and then showing their pockets, or kissing their hands to him.

They remain usually quite quiet until they have caught his eye, but as soon as that is fixed on their own, they commence making signs of all descriptions, and grinning (it can hardly be called laughing, or even smiling) with an expression as if they were greatly pleased or amused by his presence. The sounds that these cretins emit in such circumstances are sometimes almost unearthly; sometimes resembling a thick and husky laugh, choked in the very utterance.

It seems strange, that in the very places where Nature seems to have employed her vast powers and enormous resources in creating scenes to delight the eye of man, human nature should appear conspicuous in its most pitiable and degraded form! Cretinism, and goître, therefore, as well, are found to be most prevalent in the very finest valleys of the Alps. The cause of the occurrence of goître in these beautiful localities is entirely unknown; but one thing is certain, that whatever may turn out to be the cause of goître, cretinism will be found to be distinctly referable to the same cause. They are both incurable; for though the iodine which I said had been useful in certain cases has a good effect, yet it is a dangerous remedy, and one which requires great skill to be properly administered. Neither is it infallible in its action, for cases have been known in which it seemed that iodine exercised no effect whatever on the tumour. Moreover, when a youth is taken far away from his home, the affecting cause, whatever that cause may be, has undoubtedly been removed also, so that should the tumour not grow bigger, nor the cretin still continue to lose his reason, yet the removal from home cannot be termed a cure, but merely a taking away of the cause, which, if left, would further increase the complaint. Goître becomes in many cases hereditary, but I do not know that the same thing occurs with cretinism. Another method that was proposed to get rid of the tumour was to excise it. But so vascular is the swelling, that this is next to impossible. For the greater veins are out of their proper places, and the smaller ones are so well interwoven and mixed up together, that he would be indeed a bold doctor who would undertake to make a deep incision into the tumour.

These diseases affect both men and women, but in some places, especially on the north of the Alps, women are afflicted with them to a much greater extent than men. At Domo d'Ossola, the *contrary* is the case. They are not found in elevated situations,

but only in the valleys. Goître is not at all confined to Switzerland; it is known in Italy, and even to a certain extent in England.

In Derbyshire, Somerset, Hants, Surrey, and especially at Settle in Yorkshire, it is known, but not to anything like the same extent as in Italy and Switzerland. Various theories have at different times been propounded to account for the phenomena of goître. First, the practice of carrying heavy weights on their heads. Secondly, the abominable state of filth and wretchedness among which some of the peasants live. Thirdly, the snow-water which they drink. Let us see how far each of these theories will hold.

With regard to the first, it seems to me that if goître were due to the carrying of heavy loads on the head, the same would happen to many English porters, and to colliers, who, I believe, frequently carry their loads hour after hour on their heads; besides, this would not account for the goître being found in certain valleys, and being more prevalent in them than in others.

The second theory is no better, for what can be more wretched or miserable than the filth of some of our great manufacturing towns? Yet goître does not prevail in Liverpool or Bristol, or even in London.

The practice of drinking snow-water seems more likely to hold; for the water which runs down from the glaciers must be very unhealthy. The glacier was originally snow, and snow was originally cloud, and the cloud was originally evaporated from the surface of the earth. The water, then, that runs down from the glacier may be looked upon as rain-water. No water is healthy unless it contains a certain amount of impurities. The impurities in rain-water are chiefly nitric and carbonic acid and ammonia. Whereas the hard water which we are accustomed to drink contains nitrates now and then, but rarely in any quantity, also chlorides and sulphates of calcium and iron. Carbonate of calcium is present as well, held in solution by carbonic acid. Rain-water must be entirely deficient in iron and calcium salts, for they are not volatile, and hence cannot be vaporised with the water. Nitrate of ammonia and carbonic acid exist in exceedingly small quantities, and therefore snow-water may be looked upon as nearly pure. It is always coloured, but I believe that this is merely due to its having passed over sandy and light beds in its course.

To return to the goître. A serious objection to the last-mentioned theory of its origin lies in the fact, that in some parts one side only of the valley is affected, the other being entirely free from it. This was first observed by Sir Astley Cooper in 1834, and taken notice of scientifically.

Two more theories I have to mention; one of which ascribes

the goître to an excess of calcareous matter present in the spring-water or in the soil. Now, in the first place, the water generally drunk by the people is snow-water; secondly, there are many places in England where the soil is on limestone, but where no traces of goître are found. Goître is far more likely to be due to a want of a free circulation of air. Experience has shown that it prevails most in those places where water and air both lie stagnant; in moist and warm situations, where a free current of air cannot sweep past and bring away with it the polluted air and vapours stagnant in the valley. In one long valley it is perhaps found that the goître prevails at one spot, and a little higher up is unknown; a mile or two further, perhaps, it is again prevalent, and so on. This is notably the case with the valley leading up to the Great St Bernard. The disease, which is unknown at Liddes, prevails at Verchères, though it is at least 800 feet lower down. At Orsières, again, almost every one is afflicted with it. Orsières is, of course, further from the glacier than Liddes, so that if the disease originated in glacier-water, it would be found at Liddes rather than at Orsières. A fact in the ancient way of living which the Swiss used to practise may bear on this subject. They were collected together into small districts and villages, and the old superstition (though it may seem strange to us) was, that they might not live away from the villages in which they had been born, lest they should be killed by evil spirits. Consequently, a small lot of, say, one hundred live together, and breed there, generation after generation, without changing their abodes or receiving fresh inhabitants into their own villages. This alone is enough, I think, to account for many disorders. Perhaps it may have originated the one in question; but at all events the disease, once created, would be handed on, since we know that the disease is hereditary.

Something of the same sort was noticed near Borrowdale, in Cumberland, many years ago. The alarming number of idiots in those districts attracted attention; and it was also noticed that the inhabitants intermarried to a great extent. This state of things is now happily altered, and no longer are the regions about Borrowdale the seats of idiocy as formerly.

Cretinism and idiocy are by no means the same; but yet they are akin to each other, and cretinism can be looked upon as a form of idiocy. The form of goître known in England is much milder than that of the Alps and the Pyrenees. It is identical with the so-called "Derbyshire Throat." I mentioned that cretinism usually occurs about the age of puberty; but children have shown symptoms of weakness of mind, and their heads have begun to increase in size, while they were cutting their teeth.

Almost all the cretins are confirmed beggars. They never lose an opportunity of showing their empty pockets, and holding out their hands to travellers, though what they do with the money I cannot conceive. It is said that they will take anything, even a bit of cardboard of the same shape as a coin, and be just as delighted with it as if it were real. Whether this is true or not I cannot say.

It is remarkable that at Martigny, where the proportion of cretins used to be very large, the present generation is almost entirely exempt from the malady. To show the numbers of people who are afflicted by these diseases in certain valleys, it is sufficient to say, that there is one village in Switzerland where three-quarters of the males are more or less goîtred, and one in fifty is a cretin. In some valleys in Savoy the increase is trifling, though the number of cretins is great. The definite cause of cretinism is, as I said, entirely unknown; but any doctor who may in future times bring forward a cure for this mysterious and distressing ailment will, I am sure, be looked upon as a benefactor to his species.

On this paper Messrs Greene and Grenfell spoke.

J. HEWSON next read a paper on the Silkworm, on which Messrs Greene and J. Stone made a few remarks. On the proposal of J. Stone, seconded by C. C. Stevenson, C. T. Blanshard, O.C., was elected a corresponding member of the Society. During the latter part of the evening, the chair was occupied by Rev. J. Greene, the President being unavoidably absent.

MEETING, NOVEMBER 24, 1871.

The PRESIDENT in the Chair.

The fourth meeting for the term was held on 24th November. Forty-six members and visitors were present.

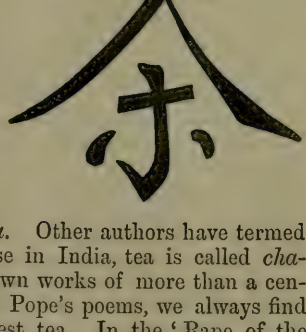
The following donations to the Museum were acknowledged by the President:—A Fossil Trunk of Tree, two large Shells, and a Piece of Coral, by W. Webb, Esq.; Slab with Fossil Plants from Bedminster Colliery, by J. Barker, Esq.; a complete collection of polished Cubes, illustrating the Clifton Rocks, purchased with Miss Wills's donation of £5; a large Crystal of Iron Pyrites by

J. E. Jose, O.C. C. B. Brownlow read a paper on 'Printing,' and Messrs Ward, Brown, Ogle, and J. Stone, added some remarks at the close.

J. F. M. H. Stone next read the following paper on

TEA.

The English name 'Tea' is borrowed from the common language of the province Fukian in China, where this article is called *tiä* in their patois. At Canton it is called *tscha* or *tschai*; black tea being named *he-tscha*, green tea *lo-tscha*. *Ch* is always pronounced *t*, and hence the difference between *cha* and *tea* for the great staple production of China; the former name for tea being adopted by the Portuguese from Macao, and the latter by the English from Amoy.



The annexed woodcut represents the Chinese character for 'tea.' It is written in ten strokes, beginning at the top on the left-hand side. The character is pronounced *cha*, the *a* as in French. The Portuguese writer Maffei, in his 'Historiæ Indicæ,' calls tea *chia*. Other authors have termed it *chaw*. In Persian works in use in India, tea is called *chakhutai* or tea of Cathay. In our own works of more than a century back, as in the *Spectator* and Pope's poems, we always find the term 'bohea' applied to the best tea. In the 'Rape of the Lock,' canto iv., Pope says—

'Where none learn ombre, none e'er taste Bohea.'

Tea is more or less cultivated for local consumption in almost every province of China, but very little black tea is exported of other growth than either of Fokien or of the Canton district, and very little green tea of other growth than that of Kiang-nan, or of the adjacent province Che-kiang.

The districts which supply the greater portion of the teas exported to Europe and America, lie between the 25th and the 31st degrees of north latitude; and the best district—that is, the one in which the finest tea is grown—lies between the 27th and 31st parallels of north latitude, on a low range of hills, which is an offshoot of the great chain Pe-ling.

The attempts which have been repeatedly made to cultivate it in Ceylon (both by Dutch and English colonists) have had but little success.

In Brazil the tea plant grows luxuriantly, especially in the vicinity of New Friburg, St Paul, and Santos; 'gaining,' says Dr Liautaud (who went thither with a commission from the French Government to inquire into its culture), 'the proportions of a third-class tree, and with a rich foliage.' 'But,' he adds, 'the Brazilian teas are too astrigent and bitter, and lack the aroma so much prized in those of China. The cost of manufacture, too, is much higher than in China.'

Hence he infers that, in the long run, the Brazilian teas will not be able to compete with the Chinese, even for home consumption. In South Carolina the experiment of tea growing was begun in 1850, by Dr Smith of Greenville; and it appears to have been carried on under sanguine expectations of success for a considerable period. Its ultimate abandonment is said to have been caused by the high price of labour, rather than by any unfavourable circumstances of soil or climate.

The following paragraph on tea-growing in America appeared in the *Every Saturday* (an American paper) for November 4, 1871.

'Tea-growing is now carried on in the various parts of the South with considerable success. A gentleman in Wilmington, N. C., has successfully raised plants and cured tea, which he claims cannot be excelled in flavour by the imported article. He obtained the plants from the agricultural bureau of the patent-office, previous to the war, and their number has increased every year, the latter plants being fully equal in every respect to those first grown. Successful experiments have also recently been made in South Carolina, Tennessee, and California, and the climate of several other sections of the United States is well adapted to this plant. California especially seems to possess peculiar advantages in this respect, and tea culture has already commenced among the Chinese who have settled there, and with the most encouraging results.'

Many attempts have been made to introduce the tea-plant into Europe; but for want of proper precautions, most of these attempts have miscarried. The seeds being of an oily nature, are apt to grow rancid during a long voyage, unless proper care is taken to preserve them. The finest tea-plant known in England was raised in Kew Gardens; but the *first* that ever flourished was one belonging to the Duke of Northumberland at Sion. The plants which are cultivated in gardens in England thrive well in the green-house during winter, and just stand that season in the open air.

Linnæus, who obtained the tea-shrub in its growing state, contrived to preserve it in the open air in the northern latitude of Sweden.

France has also procured some plants. There can be hardly any doubt but that the tea-plant would succeed in many countries of Europe if proper care were paid to its cultivation, till it became inured to the climate. A soil mixed with pieces of granite has been thought especially to suit it.

In Assam, tea was discovered in 1823, while the country was part of the Burmese dominions, by Mr Robert Bruce, who had proceeded thither on a mercantile speculation. The war with the British breaking out shortly after, and a brother of the first discoverer happening to be appointed to the command of a division of gun-boats employed in some part of the operations, he followed up the pursuit of the subject, and obtained several hundred plants and a considerable quantity of seed.

In 1834, Lord W. Bentinck appointed a committee to report as to the best method of cultivating tea in India. This committee recommended that the attempt first be made on the lower hills and valleys of the Himalayan range. Next to them, it was added, 'those of our eastern frontiers offer the best prospects, and after them, the Neilgherry and other lofty mountains in Southern and Central India.' The extremes of temperature are somewhat less here than in China. Tea is now cultivated in Assam with great success.

Tea must have been used in China from very early times. The plant, indeed, has not yet been found there in a wild state, though when the interior is explored by botanists it is most probable that it will. The tea-plant has only been found wild in Upper Assam.

A Japanese tradition, however, which ascribes its introduction to China to an Indian Buddhist priest who visited that country in the sixth century, favours the supposition of its Indian origin.

Another tradition speaks of it as early as the third century. The legend runs, 'that a pious hermit, who in his watchings and prayers had often been overtaken by sleep, so that his eyelids closed, in holy wrath against the weakness of the flesh, cut them off, and threw them on the ground. But a god caused a tea-shrub to spring out of them, the leaves of which exhibit the form of an eyelid bordered with lashes, and possess the gift of hindering sleep.'

A somewhat similar story is related concerning the introduction of coffee into Arabia.

Though now so extensively employed, the introduction of tea into Europe is of comparatively recent origin. Macpherson in his 'History of European Commerce with India,' states that tea (*sah*) is mentioned as the usual beverage of the Chinese by Soli-

man, an Arabian merchant, who wrote an account of his travels in the East, about the year A.D. 850; and that he had been unable to find any mention of it prior to the times of the Jesuit missionaries, who entered China and Japan a little before the middle of the sixteenth century.

Anderson in his 'History of Commerce' (vol. ii. p. 178), quotes Botero as giving the earliest account in 1590, when he says that they—that is, the Chinese—'have also an herb out of which they press a delicate juice, which serves them as drink instead of wine.' Texeira, a native of Portugal, about the year 1600, saw the dried leaves of tea at Malacca; and Olearius found them used in 1633, by the Persians, who obtained them from China through the agency of the Usbeck Tartars. Tulpius in his 'Observ. Medicæ,' 1641, speaks of the many virtues of the tea-plant, which he calls *thea*. Anderson says that no mention is as yet made (1660), in the new book of rates, of tea, coffee, or chocolate, though they are all mentioned in an Act of Parliament of the same year, whereby a duty of eightpence is charged on every gallon of chocolate, sherbet, and tea made for sale.

The earliest known authentic announcement of the public sale of tea appeared in the *Mercurius Politicus* for September 30, 1658. The following is the advertisement:—'That excellent and by all Physitians approved China Drink, called by the Chinese *Tcha*, by other nations *Tay*, alias *Tee*, is sold at the *Sultaness Head* Cophee-House, in Sweetings Rents, by the Royal Exchange, London.'

But the use of it at that time must have been new, for Pepys, in his Diary, writes,—'*September* 25, 1661.—I sent for a cup of tea (a Chinese drink), of which I had never drank before.'

The Dutch East India Company probably first introduced tea into Europe, and from Amsterdam it was brought to London.

In the year 1662, King Charles II. married Catherine of Braganza, a Portuguese princess, whence, Waller says, 'The best of queens and best of plants we owe to that bold nation.' Tea was, however, brought to this country in small quantities only, for in the year 1664 the East India Company purchased, for the purpose of presenting to the King, Charles II., two pounds and two ounces of tea. In the year 1678, however, they imported 4713 lbs. of tea, which was then for the first time thought worth their attention as a branch of their trade.

The genus *Thea*, in which the tea-plant is placed, is characterised by the calyx consisting of five persistent sepals, with bracts at the base, by the inner or free series of stamens agreeing in number with the petals, and by having only three styles;

while Camellia, which it closely resembles, has numerous deciduous sepals, double as many free stamens as petals, and normally five styles. The flowers of Thea are turned downwards, whilst those of Camellia are erect.

The species of the genus Thea are few in number; some botanists are of opinion that even these are only varieties of a single species.

The tea-plant (*Thea Sinensis*) is a polyandrous evergreen shrub (belonging to *Monadelphia Polyandria* of the Linnean system, and to Ternströmiacea or the 'Theads,' of Mirbel, De Candolle, and Lindley), and is of the same family as the Camellias, to one species of which (*Camellia Sasanqua*, introduced from China in 1811) it bears a very close resemblance. It usually grows to a height of from three to five feet. The stem is bushy, with numerous and very leafy branches. The leaves are alternate, large, elliptical, obtusely serrated, veined, and placed on short channelled foot-stalks. The calyx is small, smooth, and divided into five obtuse segments or sepals. The flowers are white, axillary, and slightly fragrant; often two or three together on separate pedicels. The corolla has from five to nine petals, cohering at the base. The stamens are short, numerous, and inserted at the base of the corolla. The anthers are large and yellow. The style trifid. Fruit a capsule three-celled and three-seeded.

The tea-plant thrives best on dry sunny slopes, where occasional showers fall and springs appear, and an open, somewhat stony, but rich soil prevents the water from lingering about its roots.

The following is an analysis in 200 parts of the soil in which tea grows in China:—

Silica (SiO_2)	135
Alumina (Al_2O_3)	36
Magnesium carbonate ($MgCO_3$) . .	6
Calcium carbonate ($CaCO_3$) . . .	4
Ferric oxide, (Fe_2O_3) . . .	13
Roots and fibres of plants . . .	2
Water of absorption	4

The culture of the tea-plant in China is very simple. The plants are raised from seeds, sown in the places where the future plants are to remain. Several are dropped into holes four or five inches deep, three or four feet apart. The plants grow up when the rain comes on, and require little further care, except that of removing weeds, till they are three years old, when they yield

their first crop of leaves. They are seldom transplanted, but sometimes four or six plants are put close together, so as to form a fine bush. After growing seven or ten years, they are cut down, in order that the numerous young shoots which then spring out may afford a more abundant supply of leaves. In some districts the bushes grow unrestrained ; in others, they are regularly pruned to keep them low.

A plantation of tea-plants is said to look like a garden of gooseberry bushes.

The season for gathering the leaves varies in different districts, but the principal leaf-harvest ends in May or June. They are generally gathered at three successive seasons. The youngest and earliest leaves are the most tender and delicate, and give the highest flavoured teas ; the second and third gathering are more bitter and woody, and yield less soluble matter to water.

Black tea and green tea are obtained from the same shrub, the difference between the two varieties lying solely in the mode of their preparation. In the green teas the leaves only are taken, being nipped off above the foot-stalk or petiole, while in black teas the petiole of the leaf is always collected. Thus black tea contains much of the woody fibre, while green tea is exclusively the fleshy part of the leaf itself, which is one good reason why green tea should be dearer than black.

Such are the pains taken to ensure the excellence of the finest sorts, that for two or three weeks before the harvest commences, the collectors, who are trained to this business from a very early age, are prohibited from eating fish or other kinds of food reckoned unclean, lest by their breath they should contaminate the leaves. They are also made to take a bath two or three times a day, and not even allowed to gather the leaves with the naked fingers, but always with gloves.

There are several accounts of the manner in which black and green teas are prepared, the most reliable being that of Mr Fortune, from whom we learn, says Professor Johnson in the 'Chemistry of Common Life,'—

First, That in the process of drying, the leaves are roasted and scorched in such a way as to bring about many chemical changes within the substance of the leaves themselves. The result of these changes is to produce the varied flavours, odours, and tastes, by which different varieties are more or less distinguished.

Second, That the leaves are converted respectively into green and black teas, thus causing the different colours of these two varieties.

Thus for—

Green Teas.

1. The leaves are roasted almost immediately after they are gathered.
2. They are dried off quickly after the rolling process. The whole operation is speedy and simple.

Black Teas.

1. They are allowed to be spread out in the air for some time after they are gathered.
2. They are then further tossed about till they become soft and pliant.
3. They are now roasted for a few minutes, and rolled; after which they are exposed to the air for a few hours in a soft and moist state.

Lastly, they are dried slowly over charcoal fires.

The juices and tissues of the tea-leaves contain substances which are liable to be acted on by oxygen, thereby becoming darker. When, therefore, the leaves are slowly dried, this change has time to occur in their substances. Hence slowly dried leaves yield black, quickly dried green teas.

All varieties of tea may be grouped under one of two heads, either black or green.

The various descriptions of the black tea diminish in quality and value as they are gathered later in the season, until they reach the lowest kind, called by us *bohea*, and by the Chinese, *ta-cha*, 'large tea,' on account of the maturity and size of the leaves.

The early leaf buds in spring, being covered with a white silky down, are gathered to make *pekoe*, which is a corruption of the Canton name *pak-ho*, 'white down.' There is a species of pekoe made in China from the young buds; but it is so little fired that the least damp spoils it, and for this reason, as well on account of its scarcity and high price, the Hyson-pekoe, as it has been called, has never been brought to England. In China this latter tea goes under the name *soong-tsing*.

Congou is named from a corruption of the Chinese *koong-fo*, 'labour or assiduity.' A particular variety of congou, called *campoi*, is so called from a corruption of the original name *kien-poey*, 'selection,' or 'choice.'

Souchong, from *seaou-choony*, 'small or scarce sort,' is the finest of the stronger black teas, with a leaf that is generally entire and curly, but younger than in the coarser sort. What is called *padre souchong* is packed in separate paper bundles, of about half-a-pound each, and is so fine as to be used almost exclusively for presents. The probability is that its use in that way by the Catholic missionaries first gave rise to the name.

Green teas may generally be divided into five varieties, *twankay*, *hyson-skin*, *hyson*, *gunpowder*, and *young hyson*.

Twankay tea has always formed the bulk of the green teas imported into this country, being used by the retailers to mix with the finer kinds. The leaf is older, and not so much twisted or rolled; there is altogether less care and trouble bestowed on its preparation than that of other kinds.

Hyson-skin is so named from the original Chinese term, in which connection the *skin* means the *refuse*, or exterior portion of anything. In preparing the fine tea called hyson, all those leaves that are of a coarser, yellower, and less twisted appearance, are set apart and sold as the refuse or 'skin-tea,' at a much lower price.

The word *hyson* is corrupted from the Chinese name which means, 'flourishing spring,' this fine sort of tea being, of course, gathered in the early part of the season.

Gunpowder tea, as it is called, is nothing but a more carefully picked hyson, consisting of the best rolled and roundest leaves, which give it that granular appearance whence it derives its name. It is called by the Chinese *choocha*, 'pearl-tea.'

Young Hyson, the native *yu-tsien*, 'before the rains,' was the produce of the gathering of delicate young leaves in the early spring. But the demand for it was so great by the Americans, and as it could not be fairly produced in sufficient quantities to meet the call, other green, and even black teas were substituted for it. The original or genuine young hyson is, therefore, seldom seen in this country.

In the preparation of tea, the refuse and decayed leaves and twigs are pressed into moulds, and sold under the name of *brick-tea*. These bricks are often made harder by mixing the leaves with the serum of sheep and ox blood. This inferior variety is chiefly consumed in Northern China and Thibet.

Tea is imported from China in wooden chests, always lined with thin sheet-lead, within which the tea is wrapt in a thin, though tough, silky unsized paper, which the Chinese manufacture from the liber or inner bark of the mulberry (*Broussonetia papyrifera*). The boxes are filled by the hand with tea, and then pressed down with the feet, after which the boxes are nailed up and stamped with the name of the grower or manufacturer.

In China, tea is the staple and almost sole beverage of the people. It is sold in their public-houses and towns like beer is in England. They drink it, however, unmixed with milk or sugar, and never *qualified* with stimulant, as is so often done elsewhere. The strength of the exhilarating herb is simply drawn out with boiling water.

'Whenever the tea is to be infused for use,' says Tung-po, a Chinese author, 'take water from a running stream, and boil it over a lively fire. It is an old custom to use running water boiled over a lively fire; that from springs in the hills is said to be the best, and river water the next, while well-water is the worst. A lively fire is a clear and bright charcoal fire.

'When making an infusion, do not boil the water too hastily, as first it begins to sparkle like crabs' eyes, then somewhat like fishes' eyes, and lastly it boils up like pearls innumerable, springing and waving about. This is the way to boil the water.'

The chief chemical constituents of tea-leaves may be divided into four,—

1. A Volatile Oil.
2. Theine.
3. Tannin or Tannic Acid.
4. Gluten.

THE VOLATILE OIL.

When commercial tea is distilled with water, there passes over a small quantity of a volatile oil, which possesses the aroma and flavour of the tea to a high degree.

A hundred pounds of tea yield about one pound of this oil, and to this minute quantity of its volatile ingredient the value of tea in general estimation is in a great measure due.

This volatile oil does not exist in the natural leaf, but is produced during the process of drying.

THE THEINE.

The composition of theine in one hundred parts is as follows :—

Carbon, . .	49·80
Nitrogen, . .	28·83
Oxygen, . .	16·29
Hydrogen, .	5·08
	100·00

It contains, therefore, nearly three-tenths of its weight of *nitrogen*, a proportion which exists in only a very small number of known substances.

Theine (having the formulæ $C_8H_{10}N_4O_2$) is contained in both tea and coffee; the leaves of the former containing from 2 to 4 per cent., the latter rather less than 1 per cent.

To prepare theine a cold alcoholic infusion of tea-leaves is precipitated by plumbic acetate, for the removal of the tannin which is present.

The excess of lead is precipitated from the filtrate by hydrogen sulphide (H_2S), and the liquid is evaporated to crystallisation, the crude product being purified by sublimation. Theine crystallises in long silky needles, which contain one molecule of water. The crystals are soluble in water, alcohol, and ether. When gradually heated, they sublime without decomposition. When acted upon by a nitrate and subsequently by ammonia, theine yields a purple-coloured product, similar to that obtained from an urate. When boiled with potash theine is decomposed with evolution of methylia (CNH_5). An ounce of good tea contains about ten grains of theine.

THE TANNIN, OR TANNIC ACID.

This has the composition $C_{27}H_{22}O_{17}$. It can be obtained from a solution of tea by precipitating with sulphate of iron ($FeSO_4$), or a solution of glue or gelatine. Tannin is an uncrystallisable mass, soluble in water and alcohol, but insoluble in pure ether. When heated to 215° it yields pyrogallic acid. It forms from 13 to 18 per cent. of the whole weight of the dried tea leaf, and is more completely extracted the longer the tea is infused. Tannic acid, though naturally colourless, has a tendency to become dark-coloured when exposed to the air. This is the reason why the same leaves, when dried quickly, will give a green or natural colour, and when more slowly, a black one.

THE GLUTEN.

This is the principal 'flesh-former.' According to the chemical classification of food, the '*flesh-formers*' in tea average about 18 per cent., and the '*heat-producers*' 72 per cent. Tea also contains a very small quantity of water and mineral matter.

Tea is not only adulterated in China for export, but also when it arrives in England. Among black teas adulterated by the Chinese 'scented pekoe,' 'scented caper,' and 'black gunpowder' hold a prominent place, being mixed with an imitation of tea formed of tea dust and fragments of rice, or with glazing substances, such as blacklead, indigo, turmeric, and a powder resembling mica. In green teas were detected, by Dr Hassel, Prussian blue, China clay, turmeric, and a white powder variously composed, but usually consisting of kaolin, soap-stone, or calcium sulphate. The colouring of green teas is an operation performed solely for the advantage of Europeans, the Chinese making little difficulty in exhibiting the process. 'Tea,' they sometimes say, 'is in our opinion better without Prussian blue and gypsum; but as foreigners seem to prefer an admixture of those ingredients with their tea, to make it look uniform and pretty, and as the

ingredients admired are cheap, we have no objection to supply them, especially as coloured teas always fetch a higher price.'

In England, teas are said to be sometimes mixed with the leaves of the beech, elm, horse-chestnut, willow, poplar, hawthorn, and sloe; logwood being sometimes added to make the infusion of a darker colour.

A small quantity of tea was imported from Shanghai last year, which was said to be mixed with leaf which had already been used in China and refined. It certainly was very common stuff. A great deal was written on the subject in the *Times* and other papers, and questions on it asked in the Houses of Parliament. In the end, however, the tea was sold at a very low price, and shipped to the Continent, being so common that people would not use it in this country.

Let us now consider the physiological effects of tea. As is known to all, tea exhilarates, without intoxicating. It excites the brain to increased activity, and produces wakefulness. It soothes and stills the vascular system, and hence its use in inflammatory diseases, and as a cure for headache. Green tea, when taken strong, acts very powerfully upon some constitutions, producing nervous tremblings,—in short, acting as a narcotic, and in lower animals even producing paralysis. Its exciting effect upon the nerves makes it useful in counteracting the effects of opium and of fermented liquors, and the stupor induced by fever.

The volatile oil contained in dried tea-leaves is the narcotic principle above mentioned. Tea-tasters, and those employed in packing and unpacking chests of tea, are subject to headaches and giddinesses, sometimes even ending in paralysis. This explains why the Chinese do not use tea till it is at least a year old, the effect of this keeping being to allow a portion of the volatile ingredients of the leaf to escape.

Theine has the remarkable effect of sensibly diminishing the absolute quantity of excreted substances voided in a day by a healthy man. This fact shows that the waste of the body is lessened by theine—that is, by the use of tea.

Now since the waste is lessened, the quantity of food necessary to support life will be lessened in an equal proportion,—in short, by the consumption of a certain quantity of tea, the health and strength of the body may be maintained upon a smaller supply of ordinary food.

No wonder, then, that tea should be such a favourite with the poor, old, and infirm. The former are enabled by its use to subsist comfortably on a smaller amount of solid food, and so live cheaper. In the latter, theine, by arresting the waste, keeps the body from falling away so fast, and so enables the failing powers of

digestion to supply as much as is necessary for repairing the waste of solid tissues with food. Three or four grains of theine are contained in less than half an ounce of good tea, and may be taken in a day by most persons without unpleasant effects. But if twice this quantity—eight grains—be taken in a day, the pulse becomes more frequent, the heart beats stronger, trembling comes on, and a perpetual desire to void urine. To the tannin or tannic acid contained in tea-leaves are due some of the exhilarating effects. Gluten forms as much as one-fourth of the weight of dry tea-leaves, so that if we chose to eat them, they would prove as nutritious as beans or peas. By infusing tea with water very little gluten is extracted, it has therefore been recommended that a little soda be put into the water along with it; the effect then being, that a portion at least of the gluten would be dissolved, and the beverage, in consequence, become more nutritious. The method of preparing the brick-tea, adopted by the Mongols and Tartars, is believed to extract the greater part of the nutriment from the leaf. They rub the tea to powder, boil it with alkaline water, to which salt and fat have been added, and pour off the decoction from the sediment. Of this liquid they drink from twenty to forty cups a day, and on it and a little milk they can subsist for weeks in succession.

I may here state that the reason why the gout and stone are unknown in China is ascribed to the use of tea.

The consumption of tea by the Chinese themselves is enormous; they drink four times as much tea as we do.

The population of China, according to an official census taken in 1825, was 352,866,012—more than ten times our population. Then estimating our annual consumption of tea at about 1,000,000 cwt., that of China must be about 40,000,000 cwts. England ranks next as a tea-drinking country. The annual import of Great Britain is upwards of 140,000,000 lbs., whilst that of the United States of America is about 50,000,000.

During the last year (from 1st January to 31st December 1870) the quantity of tea consumed in Great Britain amounted to 118,000,000 lbs.; the quantity exported to the continent, colonies, &c., 30,000,000 lbs.; and the quantity in stock in the English warehouses, 31st December 1870, 79,000,000 lbs.

This year (1871) the home consumption and exports will probably be very much greater, as from 1*st January to* 31*st October this year* the home consumption has already amounted to 104,000,000 lbs., and the exports to 33,400,000 lbs.

The actual tea trade is conducted as follows:—The tea for the English market is purchased and shipped from the various ports in China by merchants to London—London being the great tea

market of the United Kingdom. Now and then a vessel with a cargo of tea goes to Bristol or Dublin, but this is very seldom. On arrival in London the vessel sails into one of the large docks, and there discharges its cargo into bonded warehouses, which are under the supervision of the custom-house officers, who have them locked up every night. The merchant in London who imports the tea, or to whom it is consigned for sale, gives an order to a tea-broker to sample any portion of the teas, still under the eye of the custom-house. The broker inspects the tea, and takes away samples, values it, and reports the same to the merchant, who gives him instructions as to its sale. The tea is then sold by sample in bond—that is, *not duty paid*—at a public auction. Tea buyers are called 'The Trade,' or 'Tea-Dealers,' for they generally confine their business entirely to tea. These 'tea-dealers' again sell the tea to smaller wholesale or retail buyers all over the country, sending samples by post, or rail, or by travellers appointed for that purpose.

There is also another class of buyers who buy from the tea brokers, the exporters or shippers, who buy for shipment to Russia, the continent, America, and the colonies, though, of course, America and the Australian colonies are *chiefly* supplied directly from China. The tea-broker supplies tea to the whole trade. He receives the money when due, and hands it over to the merchant—in fact, does all the work for him—for the merchant's time is occupied with consignments of tea from China, and shipments to China, India, &c.

Black tea is used chiefly in England. Green tea is used as much as black in America. In England one-tenth only of the tea is green. The Russians consume the *finest* black teas, which they obtain by overland route from China, paying a high price for it.

China supplies the chief consuming tea countries,—viz., Great Britain, British Colonies, America, and Russia (besides what is consumed in China itself) with not less than 200,000,000 lbs. of tea annually.

Japan supplies about 15,000,000 lbs., chiefly to America.

British India exports 13,000,000 lbs. to Great Britain, being the produce of Assam, Cachar, Kargeeling, and Sythet, and a little of late from the Neilgherry Hills.

Java also produces a small quantity of tea, some of which finds its way to this country.

In countries where the tea-plant does not exist, and where a constant supply of the leaves from China is no easy matter, the people naturally look out for some substitute for tea.

At the head of all such stands the Paraguay tea or maté. The plants belong to the natural order *Aquifoliaceæ*. Its scientific

name is *Ilex paraganensis*. It is a small shrub, attaining the size of the orange-tree; leaves oval, oblong-lanceolate, remotely serrated, smooth, with umbelliferous flowers seated in the axils of the leaves. It grows wild in Paraguay and Brazil, where it is called by the Spaniards Yerva Maté.

The leaves are used largely over the whole of South America in a similar manner to the tea of China. Upwards of 40,000,000 lbs. of the leaves are annually collected in Paraguay, and sent to Chili and Buenos Ayres. Paraguay tea is not cultivated to the extent that Chinese tea is, but merchants, carrying various articles of use, penetrate into the interior, and exchange them for the leaves of the shrub which the natives collect. I need hardly say that the merchants get the best of the barter.

The mode of preparation differs from the Chinese in that the leaves, branches, and, in fact, the whole shrub is dried, and afterwards beaten and pressed into bags, and in this state it comes into the market.

When used, the leaves are steeped in boiling-water, to which a little sugar and sometimes lemon-juice are added. The beverage is drunk out of a vessel called *maté*, which has a spout perforated with holes, for the purpose of preventing the powdered leaves from passing out with the fluid. The Creoles are extremely fond of Paraguay tea, and seldom take a meal without it. The properties of maté are sedative and stimulative.

The leaves of the coffee-tree (*Coffea arabica*) are also used as a substitute for tea. Coffee-tea is much used in Java, and over the whole Eastern Archipelago. In the Dutch island of Sumatra especially, prepared coffee-leaves form 'the only beverage of the whole population, and from their nutritive qualities have become an important necessary of life.'

Labrador tea is the name given in North America to the dried leaves of the *Sedum palustre*, and *Sedum latifolium*.

Abyssinian tea, or the native Khat or Chaat, is composed of the dried leaves of the *Catha edulis*. This tea is used extensively over North Africa.

Of the other chief substitutes for tea used in different countries, the names must suffice.

Tasmanian tea, used in Australia and Tasmania.

Faham tea, used in Mauritius.

Appalachian tea, *Oswego tea*, *Mountain tea*, and *New Jersey tea*, are used in North America.

On the sanitary effects of tea, there was for a long period much controversy. 'Among many other novelties,' says a medical writer in 1722, 'there is one which seems to be particularly the cause of hypochondriac disorders, and is generally known by the

name of thea, or tea. It is a drug which of late years has very much insinuated itself, as well into our diet as regales and entertainments, though its occupation is not less destructive to the animal economy than opium, or some other drugs which we have at present learned to avoid.'

In spite of the above condemnation of tea, 'the cups which cheer but not inebriate' have always been a favourite beverage with the brain-workers, many of whom have left a lasting memorial to its harmlessness and utility.

In Greek verses, the praises of this useful shrub have been sung by Herrichen and by Francius; by Pechlin in Latin epigrams; by Pierre Petit in a Latin poem of five hundred lines.

Huet, Bishop of Avranches, has also paid his grateful tribute to a stimulant which he continued to enjoy at the age of ninety. He says:—

'I puer, I, Theam confestim in pocula misce;
Urget non solitus lumina nostra sopor;
Mens stupet; obtusæ languent in corpore vires;
Languorem volvet vivida Thea noum.'

Which may be rendered—

'Go, haste thee, boy, and make a cup of tea;
A sleep I know not presses on my eyes;
My senses wander; strength is failing me;
But with a cup of tea my languor flies.'

Waller remarks—

'The muses' friend, tea, does our fancy aid,
Repress those vapours which the head invade.'

Young says—

'Tea; how I tremble at thy fatal steam!
As Lethe, dreadful to the love of fame.
What devastations on thy banks are seen!
What shades of mighty names which once had been!
A hecatomb of characters supplies
Thy painted altars' daily sacrifice.'

Johnson describes himself as 'a hardened and shameless tea-drinker, who for twenty years diluted his meals with only the infusion of this fascinating plant, whose kettle had scarcely time to cool; who with tea amused the evening, with tea solaced the midnight, and with tea welcomed the morning.'

The same author wrote the following verses extempore to Mrs Thrale:—

'And now, I pray thee, Hetty dear,
That thou wilt give to me,
With cream and sugar soften'd well,
Another dish of tea.

'But hear, alas! this mournful truth,
Nor hear it with a frown,—
Thou canst not make the tea so fast,
As I can gulp it down.'

That the characteristic element of tea, theine, should be present, not only in the tea-plant of China and India, but in the *coffee* of Arabia and the maté-plant of South America, is in itself a remarkable fact. But when we consider that those plants containing theine should have been separated from countless others, by nations and tribes unknown to one another, and in every degree of civilisation, to draw from them an exhilarating and refreshing beverage—when we consider this, I say, we are led to believe that under the fact lies more significance than our present science has yet elicited; almost compelling us to say that tea, or its substitutes, plays an important if not necessary part, in the economy of the human race.

I know of no article of diet that has so won our affections as tea. How gradually and imperceptibly has this fascinating shrub insinuated itself into our daily food. What should we do without our evening tea? But perhaps our liking for tea may in part be attributed to the pleasant meetings of which it is the author. From the stately tea-meetings of Bath, to the merry children's tea-parties on which we all look back with pleasure, tea is the grand social mover. I cannot do better than close this paper with the words of Cowper, who thus describes the comforts of that evening meal:—

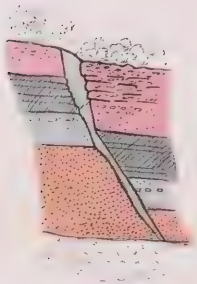
'Now stir the fire, and close the shutters fast,
Let fall the curtains, wheel the sofa round,
And while the bubbling and loud hissing urn
Throws up a steamy column, and the cups
That cheer but not inebriate wait on each,
So let us welcome peaceful evening in.'

A vote of thanks to J. Stone for his paper was proposed by the President, seconded by E. J. Crosse, and carried.

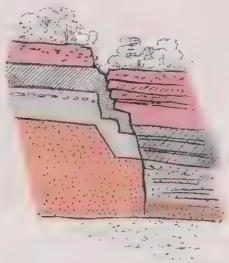
Strontian vein (a thick vein filling the fault)
Strontian (thin vein)
White Lias
Grey Marl
Dark Marl with Compact Shelly Beds
Bone Bed
Light Greenish Grey Marl
Red Marl with Pale Stripes
Gypsum
Red Sandstone
Carboniferous Limestone

AUST CLIFF

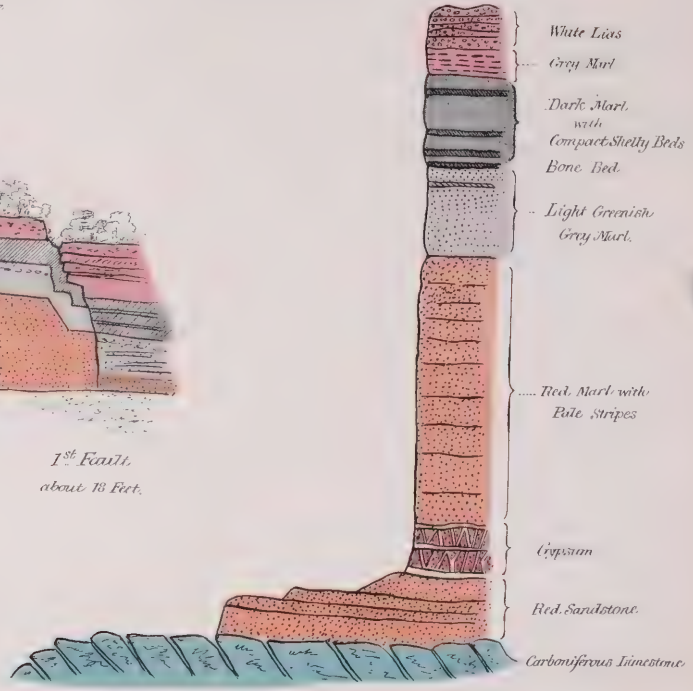
Rocks of Mountain Lime-Stone on the Beach exposed at Half Ebb.



2nd. Fault about 16 Feet



1st. Fault about 18 Feet.



MEETING, December 1, 1871.

The President in the Chair.

The fifth meeting for the term was held on 1st December. There were sixty-one members and visitors present.

The President announced the following contributions to the Museum:—Some Provincial Tokens, mostly of the eighteenth century, by W. E. Hill; ancient Indian Coins, by Colonel Lambert; fragments of a Roman Pavement and a Roman Nail, by E. K. Wedderburn; Roman and other Coins, discovered at Dover, by Mrs Buchanan; a large case of Palæozoic Fossils from Ireland, by the Irish Geological Survey. A vote of thanks to Mr Edward Hull, through whom we obtained these fossils, was proposed by the President, seconded by Rev. J. Greene, and carried. Rev. J. Greene presented, on behalf of J. Carver, Esq., Chilton Polden, Bridgewater, a very fine specimen of the Camberwell Beauty (*Vanessa antiopa*). It was taken by Mr Carver, on the 13th August 1870, while sipping the juices of an apricot tree in his garden. It has unfortunately lost its antennæ, otherwise it is in beautiful condition; and being an undoubted British example, is a most valuable addition to the Museum collection of Lepidoptera. The Secretary was directed to forward to Mr Carver an expression of thanks on behalf of the Society for his gift.

H. Wills then read the following paper on—

AUST CLIFF.

Rising from the midst of the alluvial deposits round the mouth of the Severn, are several eminences and formations of older date, belonging to the strata which underlie and skirt the alluvial plain. On the left bank of the river the principal formations to be found are the lias, triassic beds of the new red sandstone, inferior oolite, and small patches of carboniferous limestone. The beds generally are very much broken; but proceeding further away from the river we find an enormous mass of the great oolite, which extends over a wide space of the county.

Aust Cliff is surrounded by long flats of alluvial mud, while on the opposite side of the river we find a corresponding elevation, called Aunard's Cliff; the latter is lower than the former, though that never exceeds sixty feet at its highest.

It is composed of rocks resting unconformably upon the carboniferous limestone, the beds of which are very much tilted,

while the superincumbent strata are perfectly flat. The beds immediately above the limestone are triassic, composed of marls, some of which are arenaceous, and others contain selenite and gypsum.

The colour of the marls is due to the different states of the iron which they contain; both the blue and the red are essentially the same in composition, but the blue contains protoxide of iron FeO, while the red contains peroxide Fe_2O_3; in both there are traces of phosphoric acid and chlorine. It has been remarked that the carbonic acid is greater in the blue marl, because the carbonic acid, from decaying organic matter, has united with the protoxide of iron to form the carbonate.

That the selenite and gypsum should occur near together is not strange, because they are simply the same mineral. They are both sulphate of lime, containing parts sulphuric acid, 46·31; lime, 32·90; water, 20·79. When gypsum is massive it is called alabaster; when transparent, selenite. Gypsum is unquestionably, in many cases, a metamorphosed substance; for sulphurous fumes acting on beds of clay containing shells convert the lime into selenite, and acting on limestone convert it into fibrous and compact gypsum. Fibrous gypsum is found in profusion in Derbyshire, and is known under the name of satinstone, and manufactured into brooches and other ornaments. It is also found in veins and masses in the red marls bordering the valley of the Trent.

The stone commonly known as landscape marble or Cotham stone is simply an irregular nodular formation of the lias. Cotham Hill is a hummock, resembling Aust Cliff in presenting the cap of lias resting upon the base of red marl.

The following are the measurements of these strata as given in the "Memoirs of the Geological Survey of England:"—

		Ft.	Inch.
1.	Gray argillaceous limestone with shale partings; the bed, named Cotham Stone, among them; fossils—small Ostrea, Plagiostoma giganteum and striatum, modiola, species of echinites, bones,	2	6
2.	Gray marly clays,	3	0
3.	Seam of limestone,		
4.	Gray marls,	7	0
5.	Argillaceous limestone,	1	0
6.	Gray marls,	2	6
7.	Gray marls, with three beds of nodular limestone,	3	0
8.	Gray marls,	3	0
9.	Gray marls, with selenite,	5	0
10.	Argillaceous limestone, fish scales, elytra of insects, modiola, terebratula,	0	8

	Ft.	Inch.
11. Black shales,	6	0
12. Gray argillaceous limestone beds, fish scales,	0	8
13. Black shale in laminæ,	3	0
14. Thin calcareous and arenaceous bed, containing saurian remains and fish scales,	0	2
15. Black shale in laminæ,	0	8
16. The cebebrated bone bed, commonly a conglomerate, composed of rounded portions of an argillaceous and calcareous rock, mingled with saurian and fish remains and coprolites, varies from 1 to 8 inches.		
17. Pale arenaceous marls, with nodules of sandstone, calcareous cement, generally changes to an arenaceous marlstone,	1	0
18. Greenish marls, with small nodular fracture, varying in the lower part to sandy shales,	2	0
19. Marly sandstone, partly calcareous cement,	0	6
20. Arenaceous marlstone, nodular, greenish gray, and blue,	6	0
21. Red marls, with stripes, and nodules of greenish blue,	15	9
22. Red marls,	50	0
23. Gypsiferous beds, gypsum in beds and strings,	26	0
24. Red marls, somewhat sandy at the base, where they rest upon the upturned carboniferous limestone,	21	0

These beds have been the subject of much controversy. The upper beds, including the bone bed, were formerly regarded as liassic, but they are now generally considered triassic. From the fact of their corresponding to some beds in the Rhætic Alps they are called the Rhætic beds. Another name for them is the Penarth beds, because they are well shown at Penarth in Glamorganshire.

They may be divided as follows:—

Nos. 1 to 10. White lias. Fossils—Ostrea liassica, &c. No ammonites or belemnites, which occur in profusion in the lias.

Nos. 10 to 16. Black paper-shales, including the bone bed. Fossils—Avicula contorta, Cardium rhæticum, Pecten valonensis, many scales, teeth, bones, and coprolites of fish and saurians.

Nos. 17 to 20. Grey or greenish marls, not fossiliferous, and passing gradually into the variegated red marls of the keuper or upper division of the trias.

The following list of fossils characteristic of the Rhætic beds is given in Jukes' Manual.

Conchifera.—Avicula contorta, Cardium rhæticum, Modiola minima, Monotis (avicula) decussata, Ostrea liassica, Ostrea intusstriata, Pecten valonensis, Pullastra arenicola.

Crustacea.—Estheria minuta, *var.* Brodieana.

Fish.—Acrodus acutus, A. minimus, Ceratodus altus, and five others, Hybodus minor and four others, Nemacanthus monilifer, Saurichthys apicalis.

The teeth of a small mammal, supposed to be marsupial, and called Microlestes antiquus, have been found near Frome, in a fissure in the carboniferous limestone, the contents of which are supposed to be of Rhætic age.

One of the most interesting features presented at Aust is the display of no fewer than five nearly vertical faults in a cliff not exceeding a quarter of a mile in length. The distinct character and colours which belong to each of the strata, and the clear display of them which is afforded along the whole line of the section by the vertical state of the cliff, render it a most eligible spot for observing the phenomena of faults. In each case the right side has fallen, when the supporting beds have given way or disappeared from beneath. The first fault, where the cliff is lowest, is the greatest, the fall being eighteen feet. The second is the best displayed of them all; the fall is sixteen feet. The beds beneath having sunk, and with them the cliff, a crack of some feet in width is presented, which has become filled up with drift; but down the sides, between the drift and the rock of the cliff, a thick vein of sulphate of strontian has run down. A thin vein also lines the first fault. Each of the faults has acted like a dam to the rain water, which percolates through the soil, and drains over the inclined plain of the strata, giving rise to a spring which deposits a thin incrustation upon the cliff, saving it in this way from rapid destruction. The Severn continually washes away the base of the cliff, which is now quite hidden by rubbish brought away by the waters.

It now remains to describe the fossils found in the cliff, which are obtained in great profusion. Among the shells the Ostrea liassica is a small oyster.

The Plagiostoma giganteum is a common liassic bivalve, as well as P. striatum; Pecten valonensis is characteristic of these beds.

The Modiolæ are small at Aust; they are also bivalves.

Fossil fish-scales are very valuable, though not rare, on account of the facility they afford of determining the classes of fish. Those of the Mesozoic epoch are totally different from living species, and

so are classed according to their teeth and scales. Distinguished by these, M. Agassiz has divided fishes into four great classes :—

1. Placoid.
2. Ganoid.
3. Ctenoid.
4. Cycloid.

The placoid fishes have the skin covered irregularly with enamelled plates, sometimes of large size, but frequently in small points (as the shagreen of sharks).

Ganoidians are covered with brilliantly enamelled plates of an angular form, composed of horn or bone; their structure is identical with that of the teeth.

Ctenoid scales are plates, which are toothed or pectinated like a comb on their posterior margin. By being superimposed on each other, so that the lowermost edges always extend beyond the uppermost, their numerous points render them very harsh to touch.

In Cycloid fishes the scales are composed of simple laminæ without enamel, with smooth borders; but their external surface is often ornamented with markings.

In most cases the scales are imbricated, by which their true form is often concealed; if not, they resemble mere points scarcely visible to the naked eye. There are few genera destitute of scales. Teeth of fishes also serve to determine the classes. Of all the durable parts of animals found in a fossil condition, the teeth of fishes are certainly the most numerous, presenting most varied forms and structure, composition, arrangement, and attachment; yet without the aid of other parts of the skeleton, it would often be hard to decide whether an unknown tooth belonged to a reptile or a fish.

In spite of the numberless modifications in their forms, teeth can be reduced to four principal types :—

1. Conical; 2. Flattened; 3. Prismatic; 4. Cylindrical—all more or less varied. Of the conical teeth, many are long and striated at the base, like those of reptiles. The teeth are composed of a dense osseous material, of a tubular structure, called dentine; which, in many cases, forms on the external surface a hard texture, very glossy, resembling enamel. The essential character of their organisation is to have a medullary cavity, filled with a plexus of blood-vessels and nerves, from which minute tubes, forming the dentine, radiate.

The vertebræ of fishes are two hollow cones, resembling an hour-glass in shape; in life, the space between two bones is filled up with a gelatinous fluid.

The sclerotic coat, or capsule of the eye, which is bony, is also found sometimes.

The tail is the chief instrument of progression in these animals, and assumes two chief modifications. In the greater number of existing species, the tail is homocercal, or with two equal lobes, and so it is with the fishes of the upper formations. But with the magnesian limestone, we meet heterocercal, or fishes with unequally lobed tails, the backbone running out into one side alone, while the other is hardly developed.

But some of the best fossils to be obtained from Aust Cliff are the Ichthyrdorulites, or the first rays of the dorsal fins. Many extant species possess such spines, as the sharks, the rays, and common dog-fish. They are fastened in the flesh, and are attached to muscles, by which they can be raised or depressed; they are of a fibrous, osseous texture. The fossil spines occur in all the sedimentary deposits, peculiar forms appearing in the several formations. They were probably used as weapons of defence.

Among the fish of which the teeth are found at Aust is the Ceratodus emarginatus. These present a very curious appearance, and are found in the oolite as well. Their structure, in the crown of the tooth, exhibits minute vertical pores, like the Psammodus porosus: they consist of consolidated plates, instead of separate teeth; there was probably but one plate on each side of the jaws. The upper margin is generally undulated, apparently from use. The dental plates are composed of two distinct layers; the root, of an osseous reticulated tissue; the crown, of dentine.

Among the most extraordinary and rare relics to be found at Aust are the elytra of insects. These elytra are composed of the substance, called "chitine," which forms the skeleton, as it were, of insects. The front pair of wings in the coleoptera are of chitine, and protect the wings from injury, as the beetles are burrowers. Other insects are found elsewhere, chiefly libellulidæ; some wings of hymenoptera have been discovered, and a few diptera; but from the hard and enduring nature of the segments and extremities of coleoptera, they are most frequently found. The formations which have yielded most insects are the carboniferous limestone, Jurassic, especially the lithographic limestones of Solenhofen, in Germany, and the lias, and occasionally the weald, but these remains are not so common as might have been expected. The tertiary marls of the Continent, as at Aix, are, however, found to yield, among other curious fossils, some spiders and other insects.

In the lias of Wainlode Cliff, on the Severn, some specimens of minute neuropterous wings have been discovered, resembling the recent Panorpa, especially P. germanica, and have been termed P. liassica.

The elytra of coleoptera have been discovered at Stonesfield, near Oxford, and more recently at Aust; but these remains have always been detached, and in only one instance has any other part of the insect been found; that exception is a Curculio, and consists of one leg attached to the wing. The Buprestis, a family of beetles remarkable for the brilliance of their wings, has several times been discovered, especially in the iron-stone nodules of Coalbrookdale.* In these ironstones, however, an extremely valuable specimen has been extracted, displaying the elytra, thorax, and six legs, the last of which shows the enlarged femur—a characteristic feature of the Curculionidæ.

I have now to describe the bone-bed, which is very celebrated, on account of the abundance of the fossil remains obtained from it—saurian bones, fish-bones, and coprolites. These latter are excrementitious remains, solid earthy residue of digestion, generally conical and spirally convoluted. This twisted appearance is most frequently to be found in the coprolites of fishes, on account of the arrangement of their intestines. As fossils, they are chiefly interesting, as, in many cases, tending to prove the nature of the being in which, or near which, they are found; minute scales and bones of fishes being frequently found in those of the carnivora. They occur in all ages and formations.

The bone-bed, which seems to have been the cemetery of the saurians, lies, as in most cases, immediately between the Rhætic beds and trias.

The occurrence of the bed shows that over a wide area similar conditions have prevailed; patches of sea-bottoms, here and there being covered by fish remains, which could not be digested or readily eaten, and the droppings of fish being mingled with them.

The bed at Aust is a thin layer of siliceous grit, of a greenish hue, highly charged with mica, and loaded with fossil remains, among them the bones of gigantic reptiles. Siliceous strata of this type generally abound with pyrites, and are probably an under bed, coextensive with the lias throughout its course in the estuary of the Severn, and are found at Frennilode Passage, Westbury Cliff, and Aunard's Cliff, as well as at Aust. At a place called Golden Cliff, in Monmouthshire, a similar bed is found, and in Glamorganshire, near Cowbridge, at St Hilary. An extremely interesting bone-bed exists at Watchet, but the fossils are difficult to extract, being brittle, and the matrix being hard.

The saurians, the bones of which are often found, are of the Enaliosaurian division of reptiles, and are principally Plesiosauri. The animals of the genus Plesiosaurus present a remarkable devia-

* *Vide Geological Journal*, September 1871.

tion from the usual types of recent and fossil reptiles, uniting the marks of a lacertian head, crocodile's teeth, to a neck of inordinate length, with several modifications of the ribs, and four paddles of enormous size. The most striking feature in the reptile is its immense neck and comparatively small head; there are from twenty to forty vertebræ in the neck alone, which in some species is four times the length of the head, and equal to the entire length of the body and tail; while in one species (P. dolichodeirus) the head is barely one-thirteenth of the skeleton. Few skulls have been found perfect, but they are concluded to resemble in general form those of crocodiles, but are much smaller. The teeth are fixed in separate sockets, and there are about thirty or forty on each side of the jaws. They are long, conical, slender, pointed, slightly bent back, and longitudinally grooved from the base, having one long fang. The pulp cavity is long and single, the body of the tooth being firm dentine, the crown enamel, the base cement. The paddles are composed of slender bones, and possess considerable flexibility. These were air-breathing marine reptiles, and obtained considerable expansion of the pulmonary cavities by the gliding motion upon each other of the connecting bones of the ribs in the region of the abdomen.

Sixteen species of Plesiosaurus have been discovered in the British strata ranging from the lias to the chalk; they are generally to be met with in the lias and oolite.

G. Dakyns next read a paper on "Cocoa."

P. R. Ogle then read the following paper on—

FLAME.

Combustion in modern science is usually defined as chemical action attended with evolution of light and heat. The familiar forms of combustion consist of the union of the burning body with the oxygen of the atmosphere. Most combustibles which we meet with in common life consist almost entirely of carbon and hydrogen; these constituents on combustion in air are oxidised, the former to carbonic acid, and the latter to aqueous vapour; and since these products are entirely devoid of any sensible qualities, and, being in a gaseous condition, are immediately removed from the scene of action, it is easy to see how the notion arose of the annihilation of the burning body, and why the nature of the process remained undiscovered for so long a period.

The early attempts at an explanation of the phenomenon were crude and unsatisfactory, but nevertheless exceedingly interesting. An elemental body, called *Fire*, was supposed to exist, possessed of the property of devouring certain other bodies, and converting

them into itself. Thus when a fire is lit, we, according to this hypothesis, bring into contact with the coals a portion of the element *fire*, which begins immediately to consume them by converting them into that element, and what is unfit food is left behind in the form of ashes. Dr Hooke, in 1665, proposed an ingenious theory: he assumed that there existed in common air a certain substance similar, if not identical, with that fixed in saltpetre, and which gave to it its combustible character. This theory, first set forth in his *Micrographia*, was about ten years afterwards further elaborated by Mayow. To this solvent, the principle of combustion, he gives the name of *spiritus nitro-aereus*. It consists, he surmised, of minute particles constantly at variance with the particles of combustibles, and "from their quarrels all changes of things proceed;" fire consists in their rapid motion, heat in their less rapid motion. From these theories philosophers were soon directed to a theory of Beccher, which before it had become generally known, was remodelled by Stahl, and that in such an able and elegant form as soon to become universally received. He supposed that the molecules of the elementary fire or *phlogiston* were lodged in those of the body, as in so many little covers or wrappers, where they experienced a compression similar to that of a bent spring; in combustion the fire escaping in consequence of its expansive force, the particles by which the deflagation is commenced impress on the neighbouring particles a blow, which occasions their rupture by the unbending or expansion of the fire which they conceal, and the commotion thus produced would propagate the conflagration from one particle to another throughout the whole mass. So far these theories were purely physical, and took no cognisance of any change of identity in either the burning body, or in the air in which it is burnt.

Lavoisier shortly, however, pointed out that combustion was attended by an essential change in composition of the substances involved—in fact, that it was due to a combination of the particles of the burning body with those of the oxygen in the surrounding air, with an evolution of light and heat. This discovery, which was first made public in 1778, brought about a complete revolution in the scientific world; and the question may now be considered as entirely settled.

The subject of the present paper is the *light* attendant upon combustion. This may be of two kinds, *incandescence* and *flame*. The actual nature of flame, as the general phenomenon of combustion, was for long ages unknown. By the earlier philosophers it was regarded as "a simple substance reared from a combination of primordial atoms." This was the tenet of the Epicureans, but was controverted by Aristotle and the Peripatetics, who, denying

the actual existence of an elemental fire, maintained that it was but the result of the commotion of the particles of the heated body. This doctrine descended to a late period of European philosophy, and formed a part of the scientific creed of Bacon, Boyle, Descartes, and Newton, and in still later days has been revived in another form, "Heat a mode of motion." Ideas on the actual constitution of flame were always vague in the extreme. Modern science has, however, we have every reason to believe, successfully solved the difficulty. We consider flame as the particles of a gas or vapour, raised to a state of incandescence by the heat evolved from the combination of the burning body with oxygen or other supporter of the combustion. Flames frequently contain solid particles, the temporary or permanent result of the chemical changes which are taking place. It is on the presence of these particles that the luminosity of a flame depends, for the presence of solid particles in the flame raises its brightness by acting as radiant points of light.

The lecturer now proceeded to illustrate this portion of his paper. Pure hydrogen was shown to emit a feeble light when burnt in air, but on the introduction of such bodies as platinum, charcoal, &c., which could increase the radiant power of the flame, or on saturating the gas with benzole, it became luminous. Similarly phosphorus and iron, the products of whose combustion in oxygen are solids, burnt in that gas with a brilliant light; but the combustion of phosphorus in chlorine, the product being gaseous, was of feeble luminosity. Similar experiments were then tried upon an alcohol flame, with platinum, asbestos, paper soaked in calcic chloride, oxide of zinc, &c. 'Compounds containing carbon, from which a portion of the carbon is separated in the form of soot by the heat of combustion, are therefore luminous, as marsh-gas, olefiant-gas, ether-oils, fats, resins, &c. It is noticeable that the complete combustion of ether (whose flame is luminous) requires twice the amount of oxygen requisite for alcohol (whose flame is not luminous)—

$$(C_2 H_5) HO + 3O_2 = 2CO_2 + 3H_2O$$
$$(C_2 H_5)_2O + 6O_2 = 4CO_2 + 5H_2O.$$

It appears probable that, in ordinary air, all the oxygen required for the combustion of ether cannot be readily obtained, and that the unoxidised particles of the carbon act as radiant points of light.'

The non-luminous alcohol flame may be rendered luminous, by combining part of the hydrogen with chlorine, and thus freeing carbon; and the luminous coal gas flame may be rendered non-luminous by mixing it with air or oxygen, and thus completing the combustion of the carbon, as in the *Bunsen gas-lamp*. The

physical constitution of flame was now entered upon, and the various *cones* in the ordinary flames, as well as the blowpipe flames, carefully pointed out, and illustrated by diagrams, and the chemical functions of these cones noticed and illustrated by an experiment upon oxide of lead. The lecturer next proceeded to the colour of flames, the effect of heat and cold upon them—as upon carbonic oxide and hydrogen; and to the different results produced according to the nature of the substances present—as boric acid, strontic, baric, calcic, and cupric chlorides upon alcohol, hydrogen, and the Bunsen flames.

The theories as to whether in these cases the salts are decomposed and the elements freed or not; the spectra of different flames; the merely relative character of the terms combustible and supporters of combustion, illustrated by hydrogen and oxygen, were then considered; and a few words upon the principles of pyrotechny, with illustrations of mimic lightning, lycopodium, and lightning-paper,* red, green, blue, and white fires, and a short sketch of the history of the art, concluded the experimental part of his paper. He then resumed as follows:—

Flame, then, has nothing in it of an elemental character, as the ancients thought, but is merely the particles of a gas or vapour rendered incandescent, and is luminous in proportion as there are present solid particles which may act as radiant centres of light. To make it clear to you how it is that a perfectly gaseous and transparent body gives out light upon its ignition, I cannot do better than quote the following from Professor Tyndall's 'Heat as a Mode of Motion.' 'Coal gas is what we call a hydro-carbon; it consists of hydrogen and carbon in a state of chemical union. We have a surface of this compound gas in presence of our air; we apply heat, and the attractions are instantly so intensified that the gas bursts into flame. The oxygen has choice of two partners, and closes with that for which it has the strongest attraction. It first unites with the hydrogen, and sets the carbon free. Innumerable solid particles of carbon thus scattered in the midst of the burning hydrogen, are raised to a state of intense incandescence; they become white hot, and mainly to them is the *light* due. The carbon, however, in due time closes with the oxygen, and becomes carbonic acid; but in passing from the hydrogen, with which it was first combined, to the oxygen, with which it enters into final union, it exists for a time in the solid state, and

* To make lightning-paper, gunpaper is first prepared by soaking bibulous paper for about ten minutes in a mixture of four parts of strong sulphuric acid and five of fuming nitric acid, and gently drying it; the gunpaper is then dipped in a solution of either baric, strontic, calcic, cupric, or potassic chlorate, according to the colour required.

then gives us the splendour of its light. The combustion of a candle is in principle the same as that of a jet of gas. Here we have a rod of wax or tallow through which passes a cotton-wick. You ignite the wick, it burns, melts the tallow at its base, the liquid ascends through the wick by capillary attraction, it is converted by the heat into vapour, and this vapour is a hydro-carbon which burns exactly like gas. In this case, also, you have unburnt vapour within, common air without, while between both is a shell which forms the battle-ground of the clashing atoms, where they develop their light and heat.'

Whether we consider the flame of the candle, of the gas-jet, or of the fire, in each of these familiar forms there is the same weird beauty which baffles description. A strange sensation, almost amounting to awe, comes over us as we watch the flickering blaze of the fire, which, as it now leaps up with sudden rush, licks in playful fury the chimney sides, and sinks back till we almost lose it in the red glow beneath, is a fitting symbol of the soul of man; for it, too, we see now to aspire upward to the very heaven in its efforts, and now to sink back to the level of its earthly frame. To us the flame is bound not only by such æsthetical ties, but by ties of love, for in it we see the symbol of domestic life, and assuredly the family hearth is the altar of domestic happiness. To the ancients such feelings were almost unknown; with them it was not so much its beauty, but its grandeur, which won for fire the veneration with which it was regarded. Their worship was not dictated by feelings of love, but of fear; and it was, doubtless, owing to its awe-inspiring character that fire, one of the grandest agents of nature, held its sway over the ancients, ignorant as they were as to its true nature.

It was regarded amongst most nations in an early period of the world's history either as the creator and productive cause of all things, or, at least, as the substance from which the Creator produced all things. Hence the Persians, Ethiopians, Scythians, and Carthaginians in the old world, and the Mexicans and Peruvians in the new, paid divine honours to fire itself, or to the sun, which was regarded as the sublimest representation of this element. Throughout Egypt, *Pyrea*, or temples dedicated to fire, were erected at the institution of Zoroaster. To Vesta, temples in every Roman and Grecian city were erected, in which a lambent flame was perpetually burning upon the altar. Nor was this veneration for fire confined to the Pagan nations of the world. The Hebrews were early led to associate their ideas of the Deity with its presence, on account of the numerous manifestations of His presence under this symbol, so that, ever anxious to preserve it in a pure and active flame upon the national altar, we are told in

Holy Scripture that at the Persian captivity, 'the priests that were then devout took the fire of the altar privily, and hid it in an hollow place of a pit without water, where they kept it sure, so that the place was unknown to all men;' and on the restoration to liberty and return to Judea, the posterity of those priests sought for the sacred fire, 'but they found no fire, but thick water,' nevertheless this water they took up and sprinkled with it the sacrifice, whereupon the sun shone forth with unexpected brilliancy, and fire blazed upon the altar. After the conclusion of the sacrifice, the remainder of the water was poured upon the altar, and again there blazed forth fire. The scene of this miraculous occurrence was enclosed by order of the king, and made holy for ever, and called by the name of Naphthar or Nephi (2 Mac. i. 18).

MEETING, December 8, 1871.

The President in the Chair.

The sixth meeting for the term was held on 8th December. Fifty-two members and visitors were present.

The following contributions to the Museum were acknowledged by the President :—Two Fish Spines from Aust, by H. Wills; a Human Skull, Trunk Fish, and Skulls of Sheep and Turtle, by J. F. M. H. Stone; Skull of Hottentot, by J. Rossiter, Esq.; some Fossil Corals by J. E. Jose, O.C.; an additional donation of about 500 specimens of Lepidoptera, by Rev. G. Greene, including the following :—*Sesia, myopæformis, culiciformis, formicæformis, chrysidiformis, ichneumoniformis, Arctia urticæ, Orgyia cœnosa, gonostigma, Notodonta trepida, Chaomia dodonæa, Ceropacha ocularis, Acronycta auricoma, myricæ, Nonagria neurica, Acosmetia caliginosa, Agrotis lunigera, ripæ, Dicycla oo Cosmia pyralina, Epunda lutulenta, Phlogophora empyrica, Heliothis peltiger, armiger, Anarta melanopa, cordigera, Plusia interrogationis, Boarmia roboraria, Acidalia circellata.* A fiddle, made by the natives of Cape Verde, had been presented by C. Miller; the President, however, stated that he should return it, as it could not be included in the list of articles wanted for our Museum.

Mr J. WARD then read a paper on—

THE SEA-SERPENT, OR KRAKEN.

There is perhaps no animal which has caused such dispute among scientific men of all nations and times as the sea-serpent.

Its wonderful size, and the strange stories concerning it, naturally heightened by its extreme scarcity, have, as a general rule, been discredited; but of late years, Gosse and other eminent naturalists have begun to attach more importance to the stories of the much-doubted sea-serpent.

The countries that have been most frequently visited by it are Norway and North America, and occasionally our own shores. It has also been seen out at sea, and, as a general rule, within temperate climates.

Popular tradition has ascribed to it an immense serpent-like body, but the particulars will appear in the following accounts, all of which are authentic, most of the narrators being officers in the English navy, or persons of well-known character.

The first case which I shall mention is that of a gentleman who, under the title of Oxoniensis, published the following communication in the *Times* of November 4, 1848:—

'There does not appear,' says this writer, 'to be a single well-authenticated instance of these monsters being seen in any southern latitude; but in the north of Europe, notwithstanding the fabulous character so long ascribed to Pontoppidan's description, I am convinced that they both exist and are frequently seen.

'During three summers in Norway, I have repeatedly conversed with the natives on the subject. A parish priest residing on Romsdal Fjord, about two days' journey south of Drontheim—an intelligent person, whose veracity I have no reason to doubt—gave me a circumstantial account of one which he had himself seen.

'It rose within thirty yards of the boat in which he was, and swam parallel with it for a considerable time. Its head he described as equalling a small cask in size, and its mouth, which it repeatedly opened and shut, was furnished with formidable teeth; its neck was smaller, but its body—of which he supposed that he saw about half on the surface of the water—was not less in girth than that of a moderately-sized horse.

'Another gentleman in whose house I stayed had also seen one, and gave a similar account of it; it also came near his boat upon the fjord, when it was fired at, upon which it turned and pursued them to the shore, which was luckily near, when it disappeared.

'They expressed great surprise at the general disbelief attached to the existence of these animals amongst naturalists, and assured

me that there was scarcely a sailor accustomed to those inland lakes who had not seen them at one time or other.'

Two years before this, the Rev. P. W. Deinboll, Archbishop of Molde, published the following account:—

'On the 28th of July 1845, J. C. Lund, bookseller and printer; G. S. Krogh, merchant; Christian Flang, Lund's apprentice; and John Elgenses, labourer, were out on Romsdal Fjord fishing. The sea was, after a warm sunshiny day, quite calm.

'About seven o'clock in the afternoon, a little distance from shore, near the ballast place and Mold Hooe, they saw a large marine animal, which slowly moved itself forward, as it appeared to them, with the help of two fins on the fore part of the body nearest the head, which they judged from the boiling of the water on both sides of it. The visible part of the body appeared to be between forty and fifty feet in length, and moved in undulations like a snake. The body was round and of a dark colour, and seemed to be several ells in thickness. As they discerned a waving motion in the water behind the animal, they concluded that part of the body was concealed under water. That it was one connected animal, they saw plainly from its movement. When the animal was about 100 yards from the boat, they noticed tolerably correctly its fore part, which ended in a sharp snout; its colossal head raised itself above the water in the form of a semicircle; the lower part was not visible. The colour of the head was dark brown, and the skin smooth. They did not notice the eyes, or any mane or bristles on the throat. When the serpent came within musket-shot, Lund fired at it, and was certain that the shot hit it in the head. After the shot he dived, but came up immediately.

'He raised his head like a snake preparing to dart on its prey. After he had turned and got his body in a straight line, which he appeared to do with great difficulty, he darted like an arrow against the boat. They reached the shore, and the animal, perceiving that it had come into shallow water, dived immediately, and disappeared in the deep.'

Such is the declaration of these four men; and no one has any cause to doubt their veracity, or imagine that they were so seized with fear that they could not observe what took place so near them.

This concludes all the Norwegian evidence that I intend to mention. My next account is from a report published by the Linnean Society of New England, in 1817, relative to a large marine animal, supposed to be a serpent, seen near Cape Ann, Massachusetts.

Of the eleven deponents who certified their evidence before magistrates, the serpent form was attested by all; the length was variously estimated between 50 and 100 feet. No appearance of mane was seen by any. The head was about the size of a horse's,

and in shape like that of a sea-turtle, rattlesnake, and serpent generally.

Five witnesses speak of dorsal protuberances, four say the body was straight, and the rest don't discuss the point.

The magistrate who saw the animal, and to whom the body appeared straight, considers that the appearance of protuberances was due to the vertical bendings of the body during energetic motion.

About fifteen years afterwards, five British officers saw the sea-serpent. The following is the evidence they gave :—

'On the 15th of May 1833, a party, consisting of Captain Sullivan, Lieutenants Maclachlan and Malcolm of the Rifle Brigade, Lieutenant Lyster of the Artillery, and Mr Ince of the Ordnance, started from Halifax in a small yacht for Mahone Bay, some forty miles eastward, on a fishing excursion.

'We were enjoying ourselves on deck, smoking our cigars and getting our tackle ready for the approaching campaign against the salmon, when we were surprised by an immense shoal of grampuses, which appeared in an unusual state of excitement, and which in their gambols approached so close to our little craft that some of the party amused themselves by firing at them with rifles. At this time we were jogging on at about five miles an hour, and must have been crossing Margaret's Bay. I merely conjecture where we were, as we had not seen land since leaving Pennant Bay.

'Our attention was presently diverted from the whales and "such small deer," by an exclamation from Dowling, our man-of-war's-man, who was sitting on the leeward, of, "Oh, sirs, look here!" We were startled into a ready compliance, and saw an object which banished all other thoughts save wonder and surprise.

'At the distance of 150 to 200 yards on our starboard bow, we saw the head and neck of some denizen of the deep, precisely like those of a common snake, in the act of swimming, the head so elevated and thrown forward by the curve of the neck as to enable us to see the water under and beyond it.

'The creature rapidly passed, leaving a regular wake, from the commencement of which to the fore part, which was out of water, we judged its length to be about eighty feet; and this within, rather than beyond the mark. We were, of course, all taken aback at the sight, and, with staring eyes and in speechless wonder, stood gazing at it for full half a minute. There could be no mistake, no delusion, and we were all perfectly satisfied that we had been favoured with a view of the "true and veritable sea-serpent," which had been generally considered to have existed only in the brain of some Yankee skipper, and treated as a tale not much entitled to belief. Dowling's exclamation is worthy of record, "Well, I 've sailed in all parts of the world, and have seen

rum sights too in my time, but this is the queerest thing I ever see!" and surely Jack Dowling was right. It is most difficult to give correctly the dimensions of any object in the water. The head and neck of the creature we set down at about six feet in length; the extreme length, as before stated, at between eighty and one hundred feet.

'The neck in thickness equalled the trunk of a moderate-sized tree.

'The head and neck were of a dark brown or nearly black colour, streaked with white in irregular streaks. I do not recollect seeing any part of the body.

'Such is the rough account of the sea-serpent, and all the party who saw it are still living,—Lyster in England, Malcolm in New South Wales with his regiment, and the remainder in Halifax.

'W. Sullivan.
'A. Maclachlan.
'G. P. Malcolm.
'B. O'Neal Lyster.
'Henry Ince.'

I now mention a very important case, given as it was in an official report to the Lords of the Admiralty, by Captain M'Quhæ, which gave rise to a great amount of discussion, and fresh accounts were brought forward at the date of its publication in the *Times*.

'Her Majesty's Ship *Dædalus*,
'Hamoaze, *October* 11, 1848.

'Sir,—In reply to your letter of this date, requiring information as to the truth of a statement published in the *Times* newspaper, of a sea-serpent seen from Her Majesty's Ship *Dædalus*, under my command, on her passage from the East Indies, I have the honour to acquaint you, for the information of my Lords Commissioners of the Admiralty, that at five o'clock P.M. on the 6th of August last, in latitude 24° 44′ S., and longitude 9° 22′ E., the weather dark and cloudy, wind fresh from the N.W., with a long ocean swell from the S.W., the ship on the port tack heading N.E. by E., something very unusual was seen by Mr Sartoris, midshipman, rapidly approaching the ship from below the beam. The circumstance was immediately reported by him to the officer of the watch, Lieutenant Edgar Drummond, with whom and Mr William Barett, the master, I was at that time walking the quarter-deck. The ship's company were at supper.

'On our attention being called to the object, it was discovered to be an enormous serpent, with head and shoulders kept about four feet constantly above the surface of the sea, and as nearly as we could approximate, by comparing it with what our main top-

sail would show in the water, there was at the very least sixty feet of the animal *à fleur d'eau* (at the surface of the water), no portion of which was, to our perception, used in propelling it through the water, either by vertical or horizontal undulation.

'It passed rapidly, but so close under our lee quarter, that, had it been a man of my acquaintance, I should easily have recognised his features with the naked eye; and it did not, either in approaching the ship or after it had passed our wake, deviate in the slightest degree from its course to the S.W., which it held on at the pace of some twelve or fifteen miles per hour, apparently on some determined purpose.

'The diameter of the serpent was about fifteen or sixteen inches behind the head, which was, without any doubt, that of a snake; and it was never, during the twenty minutes that it continued in sight of our glasses, once below the surface of the water; its colour, a dark brown, with yellowish white about the throat. It had no fins, but something like the mane of a horse, or rather a bunch of seaweed, washed about its back.

'It was seen by the quarter-master, the boatswain's mate, and the man at the wheel, in addition to myself and the officers above mentioned.

'I am now having a drawing of the serpent made from a sketch taken immediately after it was seen, which I hope to have ready for transmission to my Lords Commissioners of the Admiralty by to-morrow's post.'*

'PETER M'QUHÆ, *Captain.*

'To Admiral Sir W. H. Gage, G.C.H., Devonport.'

Amongst the testimony brought forward by this last report was that of Mr J. D. Morries, Stirling, a gentleman who had lived in Norway.

In a report that he made to a scientific body at Bergen, he says,—

'Three years ago, while becalmed in a yacht near Bergen and Sogn, in Norway, I saw, at about a quarter of a mile astern, what appeared to be a large fish ruffling the otherwise smooth surface of the fjord, and, on looking attentively, I observed what looked like the convolutions of a snake. I immediately got my glass, and distinctly made out three convolutions, which drew themselves slowly through the water. The greatest diameter was about ten or twelve inches. No head was visible; and, from the size of each convolution, I supposed the length to be about thirty feet.

'The master of my yacht (who as navigator, seaman, and

* The sketch alluded to appeared in the *Illustrated London News* of Oct. 28, 1848.

fisherman, had known the Norwegian Coast and North Sea for many years), as well as a friend who was with me, an experienced Norwegian sportsman and porpoise-shooter, saw the same appearance at the same time, and formed the same opinion as to form and size.

'I mention my friend being a porpoise-shooter, as many have believed that a shoal of porpoises following each other has given rise to the fable, as they call it, of the sea-serpent.'

Professor Owen in an article criticised the report of Captain M'Quhæ, saying that it was his opinion that the animal seen was a seal that had got drifted into warm latitudes, and that the iceberg on which it had been carried was probably melted when seen by Captain M'Quhæ.

The ground of this conclusion was that the head of the animal in the drawing was not at all like a snake's head, although it was affirmed that it was undoubtedly such; and also because if it had been a serpent its head and neck would have been thrown into motion by its exertions in progression, while it is stated that the closest inspection failed to detect any undulations of the body.

To this Captain M'Quhæ wrote in reply, saying that it was certainly not a seal, its great length, and its totally different physiognomy, precluding the possibility of its being such.

During the last few months several visits of this wonderful animal have been reported. This first short paragraph is taken from the *Western Daily Press* of October 19, 1871.

'A correspondent of a London evening paper recently saw at St Lawrence-on-the-Sea, near the Foreland, a huge fish more than fifty feet long. It was swimming at the rate of from forty to fifty miles an hour. The striped back was distinctly seen by all.

'Two friends who were with the correspondent at the time were also witnesses of the sea monster's appearance.'

This next account is from the *Limerick Chronicle* of the 5th October, 1871.

'On Tuesday last, a party of strangers staying at Kilkee, composed of several ladies and some gentlemen, one of whom is a well-known clergyman in the north of Ireland, went down to see, among other points of interest, a place known as the "Diamond Rocks," and remained there for some time watching the heavy ground-swell from the Atlantic, which came dashing in with tremendous force against the cliffs. The clergyman before mentioned (who is our informant) states, that all of a sudden their attention was arrested by the appearance of an extraordinary monster, who rose from the surface of the water about seventy yards from the place where they were standing; it had an enormous head, shaped somewhat like a horse, while behind the head and on the neck was

a huge mane of seaweed-looking hair, which rose and fell with the motion of the water; the eyes were large and glaring, and by the appearance of the water behind a vast body seemed to be beneath the waves. As the creature was coming "towards" our informant, he was unable to judge of its length with the same accuracy as if it had been proceeding in a parallel direction; but all agreed that it was the most gigantic creature they had ever seen. One of the ladies nearly fainted at the sight, and all had their nerves considerably upset by the dreadful appearance of this extraordinary creature; its movements were apparently feeble, and gave the idea of exhaustion as it slowly rose to the top of each succeeding wave, raising its huge head above the surface as it did so, and then as slowly sank into the trough between the waves. The whole appearance lasted for some minutes, till at length the creature sank in the sight of all about a gunshot from the shore, and vanished in the same mysterious way that it had come!'

The clergyman here mentioned, Rev. John P. Brown, remarks in a letter to me on the subject:—'The head was very similar to that of a horse, but the expression, if I may use such a term, was that of a baboon, the hair coming out on the face, very thick and matted on the neck.'

The sea-serpent seems most probably to be very closely allied to the 'plesiosaurus,' for that would, most likely, present such an appearance when swimming as the numerous accounts describe.

With regard to the mane, I think that it, like the human beard, may belong to one sex only.

That none of its remains have ever been found, even in Norway, where it is most plentiful, is but natural, when we consider the steep rock-bound coast of that country.

Gosse, in speaking of this subject, says, 'In conclusion, I express my own confident persuasion that there exists some oceanic animal of immense proportions which has not yet been received into the category of scientific zoology; and my strong opinion is that it possesses close affinities with the enaliosauria of the lias.'

Much interesting information on this subject was added by Messrs M. J. Barrington-Ward, Allen, and Rev. J. Greene. The thanks of the meeting were given to M. J. Ward for his entertaining paper.

The President announced that the Committee had elected Professor Lawson, Oxford, an Honorary Member.

The monetary accounts of the Society were then read by the Treasurer, and passed.

MEETING, DECEMBER 15, 1871.

The PRESIDENT in the Chair.

The seventh and last meeting for the term was held on 15th December. Thirty-nine members were present.

The following donations were acknowledged :—£10 for purchasing the Palæontographical Society's Books, for the Society's Library, by T. Proctor, Esq. ; fine specimens of Stalactitic Iron, Iron Ore, and Pig-iron, from the forest of Dean, by H. J. Greenham, Esq. ; Seed-vessels of the Sacred Lotus (*Nelumbium speciosum*), by Professor Lawson ; a specimen of Large Tree Fungus (*Polyporus ulmarius*) from an elm, by C. T. Blanshard, O.C. ; a collection of Local Dried Ferns, mainly made by Mr Thwaites of Ceylon, by Rev. J. Heyworth ; a collection of Local Fossils, by J. Rossiter, Esq.

The business of the meeting was the election of office-bearers for next term.

For the office of Treasurer J. Allen was elected. The other candidates were C. C. Stevenson, D. Pearce, and G. Dakyns.

Thirteen candidates were brought forward for the vacant seats on the Committee, and from them the following were elected :— Rev. J. Greene, J. Stone, T. H. Warren, D. Pearce, and R. B. Don.

A vote of thanks to M. J. Barrington-Ward, Esq., for the able manner in which he had performed the office of President during the past term, was proposed by Rev. J. Greene, seconded by J. F. M. H. Stone, and carried unanimously. C. C. Stevenson proposed a vote of thanks to the Committee, which was seconded by H. Wills, and passed.

FIRST TERM, 1872.

MEETING, FEBRUARY 2.

The PRESIDENT in the Chair.

A PRELIMINARY meeting of the Society was held on 2d February. Twenty members were present.

The President stated that the Committee had elected W. D. L.

Macpherson, Esq., an Honorary Member, and that J. F. M. H. Stone had been appointed Secretary for the term.

The election of Directors of Sections then occupied the meeting. The following candidates were proposed by the Committee:— Archæology, W. D. L. Macpherson, Esq.; Zoology, D. Pearce; Botany, M. J. Barrington-Ward, Esq.; Geology, J. G. Grenfell, Esq.; Entomology, J. F. M. H. Stone; Physics, W. Smith; Chemistry, P. R. Ogle. For the chemistry section W. J. P. Wood was elected; for the other sections the candidates proposed by the Committee were elected. J. E. Pearson, O.C., R. F. Brunskill, O.C.; M. J. Ward, O.C., were elected Corresponding Members of the Society.

In reference to sectional meetings, P. R. Ogle brought forward the following motion:—'That at least two meetings of each section be held every term.' The motion was seconded by W. G. P. Wood, and carried by a majority of twelve votes.

The Secretary read the following rules which had been drawn up and passed by the Committee:—

That Honorary Members be elected for *two* years only, but if re-elected after that period be not obliged to pay any further subscription.

That Honorary Members, on the payment of the single sum of one guinea, or the annual one of five shillings, shall receive a copy of each number of the Transactions post free.

That Corresponding Members be elected for five years only, but on signifying to the Secretary in writing their desire to remain on the Society's books, at the termination of that period, they be allowed to do so.

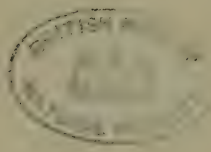
MEETING, February 9, 1872.

The President in the Chair.

The first regular meeting for the term. Thirty-nine members and visitors were present.

The President read an account from the Bristol papers of the death of Rev. Canon Mosely, M.A., an Honorary Member of this Society.

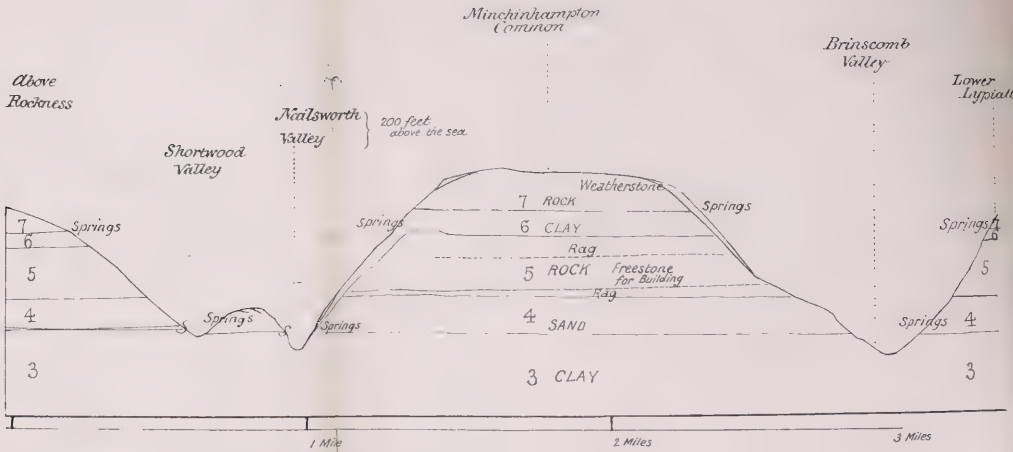
The following donations were acknowledged :—Two hundred



coarse limestone, with terebratulæ and other shells, and is sandy in parts.

A circle with a radius of four miles will cover the extent of ground around Minchinhampton described in this paper. The whole district is extremely hilly ; valleys run far into the ranges

Section of Minchinhampton Common and the Neighbourhood.



3 Lias 4 Sand 7 Great Oolite
5 Inferior Oolite
6 Fuller's Earth

The following donations were acknowledged :—Two hundred and fifty Plants for the Botanic Garden, from G. Maw, Esq.; stuffed specimens of Male and Female Redgrouse (*Tetras tetrix*), from Rev. J. Heyworth; a Brick from the Roman baths of Minerva at Bath, from J. F. M. H. Stone; Fossil Plants from the coal measures, and a specimen of Hæmatite, from W. Oliphant; some Birds' Eggs, from C. Hill; large number of Tokens of seventeenth and eighteenth centuries, from H. Davies; an interesting specimen of the Skull of a Rabbit, in which the upper incisors had grown abnormally, from H. R. Carver; an abnormal Hen's Egg, from Mrs Percival; an Egg of Nightingale (*Philomela luscinia*), from D. Wilkie; a number of Coins and Medals, from J. Gibbons; the Skull of a Jay (*Garrubis glandarius*), from T. Twist; lower Jaws of Hedgehog (*Erinaceus europaeus*), from A. Cole Hamilton; Skin of Lesser Grebe (*Podiceps minor*), Eggs of Merganser (*Margno merganser*), and Arctic Tern (*Sterna macroura*), and Covering of Dogfish's Egg (*Spinax acanthias*), from J. Swinburne; Coal from the Indian Ocean, from the President.

H. Wills next read the following paper on—

THE OOLITE AT MINCHINHAMPTON.

The oolite is a marine formation of great extent and thickness, consisting of clays and limestones, abounding in marine shells, corals, fishes, and land and sea reptiles, some plants, and several insects. It is divided into upper, middle, and lower oolite, which latter is again divided into the lower oolite of Gloucestershire, that of Scotland, and that of Yorkshire, all presenting several distinguishing features. The oolite of Gloucestershire is subdivided into five parts, of which three, the great oolite, fuller's-earth, and the inferior, are found at Minchinhampton. The great oolite is a calcareous oolitic limestone and freestone, containing reptiles and corals, with shells in the upper beds. The fuller's-earth beds consist of marls, clays, and fuller's-earth. The inferior oolite is a coarse limestone, with terebratulæ and other shells, and is sandy in parts.

A circle with a radius of four miles will cover the extent of ground around Minchinhampton described in this paper. The whole district is extremely hilly; valleys run far into the ranges

of hills, and together with the quarries, leave many sections of the rocks which afford excellent opportunities for examining them. The Bath or compound great oolite, is found at the top of most of these hills, and near Minchinhampton, broken up by the great Brinscomb and Woodchester valleys. At the bottom of these valleys is a layer of clay, covered by a thin layer of sand, above which comes the inferior oolite, then the fuller's-earth, and at the top the great oolite, in the exact order of deposition. The inferior oolite is chiefly ragstone, while the upper beds are called weatherstone. These attain a thickness of 130 feet, the mineral character of the beds presenting the greatest variety, it being not unusual to find rich, shelly limestone passing into sandstone in the same quarry. The great oolite proper may be conveniently divided into three parts, the upper and lower of which are fossiliferous, the middle barren. Several of the upper beds are hard, and the fossils are seldom obtained entire, while the stone of the lower part admits being divided with a knife. This lower subdivision is 35 or 40 feet thick. The uppermost portion of this series, called planking—the local name denoting any thin-bedded stone —is 8 or 10 feet in thickness, and contains many fossils, several of them being trachelipods, of which I shall have to speak afterwards. Under this comes an incoherent sandstone, almost destitute of shells. Gradually the shells become more numerous, and rest on several beds of the hard shelly rock called weatherstone. A little lower down, the structure of the organic remains impart such a hardness to the rock that fire is struck by workmen's tools. These shelly beds are extremely durable, but of coarse aspect; when once dried by exposure to the sun, they do not readily absorb water, and consequently resist frost.

Beneath these beds we find the fuller's-earth, which is only imperfectly developed within the district. It consists of a series of blue and brown marls, and clays traversed by three or four bands of hard argillaceous rock, locally known as clay-rag. Some portions of these clays, and more especially the ragstones, are made up of the valves of the *Ostrea acuminata*, the only fossil of the series which is not peculiar to any bed. The numerical proportion of generally known species that are obtained from the great oolite are—Bivalves, 160; univalves, 140; radiaria, 13 or 14; cephalopoda, about 10. Of the latter, 6 are ammonites, which are, however, extremely scarce—in fact, the cephalopoda are seldom found in the beds between the inferior oolite, in which they abounded, and the Oxford clay and Portland oolite.

In the middle of the inferior oolite, a band of freestone is found which is used for building, surrounded on both sides by ragstone. Several fossils are found here also. The sand which succeeds

below is placed by some in the lias, above which it rests, but from the nature and appearance of the fossils I consider it to belong to the oolite. It is seldom found; one portion crops out in the fernery of one private house, and another close by the gate of a second. The fossils are mostly ammonites, with a few *terebratulæ*. Close by this sand is a dislodged bed of the clay, which is constantly falling down. In it rise several springs. One, which is in the garden of a private house, is an encrusting well. These are usually called petrifying wells, but that is a mistake; the water has not the property of turning the leaves, twigs, and such bodies into stone, but merely covers them with a coating of the mineral which it holds in solution. The great oolite contains, besides the fossils above enumerated, several echinodermata—cidarites and echinobrissi—and several spines, but these latter are always detached, and a considerable distance from the rest of the fossil. The echinites are often covered with papillæ, which fit into cavities at the base of the spines, which are only supported by the capsular envelopment of the common covering; but in some cases the large spines are attached by a ligament passing from the centre of the socket, which is received in a perforation in the papilla. The spines present a cellular structure, and when large enough to be divided, form excellent objects for microscopic slides. Many of the specimens from the oolite are of the flat kind, called *clypei*, but these are not so common as the rest.

Another interesting class of fossils obtained from the great oolite is the family of the *Crinoidæ*. These remarkable remains are found as early as the Silurian, but are not often found above the oolite. The most perfect are obtained from the lias, seldom more than ossicula and portions of the column being obtained higher up. These detached osselets are called entrochi. The two commonest species are pentacrinite and encrinite; a third, called apiocrinite, is found in the Bradford clay, of which there are excellent specimens in the British Museum. The ossicula, of which the skeletons of all these animals were composed, resemble those of the starfish; their use was to form a solid support for the body to protect the viscera, and to form the foundation of a system of contractile fibres which ran through the whole animal. The bony portions formed the great bulk of the animal, as they do in starfishes. The calcareous matter of these little bones was probably secreted by a periosteum, which in cases of accident, to which bodies of such delicate structure must have been particularly exposed, seems to have had the power of repairing injuries. The number of bones in these animals is astonishing, as many as 26,000 have been counted in an encrinite, irrespective of the column by which it was attached to the rocks:—20 bones in the

cup part of the animal; 10 arms, with 6 bones in each arm; hands—each hand has two fingers, each of which consists of at least 40 ossicula, these, in 20 fingers, give 800; tentacula, 30 proceeding from each of the 6 bones in each of the 10 arms, 1800; 30 proceeding from each of 800 bones of the fingers, 24,000—total, 26,000. It has been observed that this number would be immensely increased if the minute calcareous plates that are woven into the integument of the abdomen could be taken into account. All these parts are piled on the top of a slender shaft, which consists of innumerable joints, and is possessed of a high degree of flexibility. To give the requisite amount of flexibility, the joints present an extremely varied appearance, both in external and internal forms and dimensions. The column is attached to the ground by an enlargement of the base; the joints articulate firmly with each other; there is an aperture through the midst with a small alimentary cavity descending from the body to the base. Pentacrinites, which appear to be allied to the star-fishes, abound in the lower beds of the oolite and in the lias. The upper portion of the vertebral column is constructed like that of the encrinite; all the joints present a pentagonal starlike form, whence their name of starstones or asteriæ; the surfaces were covered by lines of minute teeth, locking into the interstices on the corresponding surface of the next vertebra, and so disposed as to admit flexure in all directions, without risk of dislocation. The columnar joints of *P. Briareus* are disposed in pieces alternately thicker and thinner, with a still thinner joint between them. As the root was usually fixed to the bottom of the sea, or some body floating in it, the jointed column had to change the position of the body either for food or to yield to the direction of the currents; the root was probably slight and easily withdrawn from the ground to which it was attached. The absence of large solid secretions, like those of the apiocrinites, by which the pentacrinite could have been fixed permanently to the ground, and the fact that it is found in contact with drifted portions of wood which are converted into jet, tend to prove that it was a locomotive animal, with the power of attaching itself temporarily to extraneous floating bodies or rocks at the bottom of the sea, either by its side arms or the small articulated root. The side arms gradually become smaller towards the top of the column, and sometimes number about 4000. These, when expanded, would act as nets to hold the prey or help to keep the animal to its hold on the rocks, &c. In rough water they would close and fold up along the column in such a position as to expose the least possible surface.

The abdominal cavity is rarely preserved in its fossil state, but it formed a funnel-shaped pouch of considerable size, composed

of a membrane, covered externally with many hundred angular calcareous plates of minute size. At the apex of this funnel was an aperture forming the mouth, which extended like a proboscis when required to receive food; this is situated in the centre, surrounded by the arms. The body is small; the arms and fingers long and spreading, furnished with numerous tentacula; each joint is armed at its margin with a small tubercle acting as an organ of prehension, but the form of it varies in almost every joint; these arms, with all their apparatus when expanded, must have formed a net of much greater activity than even the encrinite. We have seen that the bones of the encrinite exceed 26,000; those in the fingers and tentacles of Briareus must amount to at least 100,000, to which must be added 50,000 ossicula of the side arms (and the number is probably really far greater); thus the total number will exceed 150,000 bones, to each of which were attached two fasciculi of fibres, which served as muscles.

But, as we have already seen, the shells constitute by far the greater portion of the fossils. The weatherstones, where they chiefly abound, must have been the deposit of shallow seas, where the bodies were subjected to continual trituration. This accounts for the poor state of preservation in which the ammonites and other shells of delicate structure are found. These ammonites can only be drifted specimens, as they usually inhabited deep seas; therefore, where ammonites are found in any profusion, the beds are thick, and, as a rule, the shells are well preserved. These cephalopods are nearly allied to the nautili, but the place and use of the shell has puzzled many naturalists. Cuvier himself, judging from the small size of the outer chamber where the animal lived, supposed that they were internal shells. He probably came to that conclusion from having seen only imperfect specimens. The outer chamber is seldom preserved entire, but when it is, we find that it bears quite as large a proportion to the rest of the shell as that of the nautilus bears to the chambered interior of that shell. The shells had to serve for protection and as floats, and consequently they are but thin, to admit easy rising to the surface. Their shape is one continuous arch, coiled spirally round itself, so that the base of the outer whorls rest upon the crown of the inner, and thus the keel or back is capable of resisting great pressure. Moreover, the shell is further strengthened by ribs or transverse arches, which give many species their characteristic features. Another source of strength is the elevation, in some species of ammonites, of parts of the ribs into dome-shaped tubercles, by which the power of the simple arch is greatly increased. The foliated transverse plates were added doubtless for the same purpose. The most important organ

in the whole ammonite was the siphuncle, a means of hydraulic adjustment by which the animal regulated its ascent or descent. The exact arrangement is not clearly made out, but it seems to have been connected with a large sac or pericardium inside the animal, which was filled with fluid, the shell being caused to sink when the fluid was expelled from the pericardium into the siphuncle, and rising when the fluid was again withdrawn into the sac. The difference between these tubes in the nautili and ammonites is, that the nautili have them in the centre of the chambers and ammonites against the back, sometimes causing a ridge upon that part. Another interesting class of fossils is the belemnites. They occur in every stratum of the secondary formations, generally in great profusion, but only sparsely in the great oolite at Minchinhampton. They were the supporting bones of a species of sepia, corresponding to the large white bones of cuttlefish picked up at the present day. It is, therefore, an internal shell of compound structure made up of three essential parts,—First, a fibrocalcareous cone-shaped shell, terminating at its larger end in a hollow; then a thin conical horny sheath or cup from the base of the fibrous cone, enlarging rapidly and extending outwards to a considerable distance (this cup contained the inkbag and other viscera); and lastly, a conical chambered shell within the cup, called the phragmocone or alveolus; it was divided by thin transverse plates into air-chambers or areolæ, which were perforated by a continuous siphuncle placed on the inferior margin.

The nautili belong to Owen's order of *Tetrabranchiata*. Three species are found at Minchinhampton. They roughly resemble a disc, and are much convoluted, sometimes compressed; the whorls are contiguous, the last one generally widening at the mouth so as to cover the rest; the septa are transverse and concave, with the perforation for the siphuncle more or less in the centre. The first species is *Nautilus disponsus*—a large round and smooth shell with the back of the whorls rounded; the mouth very large. Only one specimen has been obtained from Minchinhampton; but four miles off, in Woodchester, it is more common.

The smaller fossils of the neighbourhood are by far the most numerous. Dr Buckland ("Bridgewater Tr.," vol. i., p. 299) has remarked that in the strata from the chalk downwards, carnivorous univalves are rare, though extremely abundant in the tertiary rocks, and brings forward the trachelipods as an instance. However, in the uppermost portion of that part of the great oolite called the planking, a bed eight or ten feet in thickness, we find a numerous set of these trachelipods, and of the 141 species of univalves, 45 at least are carnivorous, comprised in about seven genera. The extreme scarceness of the cephalopoda

is the more remarkable, when taken in connection with the abundance of the carnivorous genera; but the same answer can still be returned, that the rocks in question were the deposits of a shallow sea, while the cephalopods lived in deep water. An extremely common fossil is the terebratula, of which there are several species—one especially, *Terebratula fimbria*, is so abundant in a stratum of the inferior oolite that it is called the fimbria bed, consisting of marly rock and cream-coloured marls. Another species, *T. costata*, is found quite separate, and the species are seldom obtained together. Another remarkable species, *T. Digona*, is obtained near Tetbury. At the base of Frocester Hill, curious fossils are sometimes obtained—*Rhynchonella Cynocephala*, so called from a rough resemblance to a dog's head.

A family of univalves, the Patellidæ, much resembling the modern limpet, has many representatives at Minchinhampton,—the first species, *P. Cingulata*, being found near Brinscomb; a few specimens of the *P. paradoxa*, have been discovered in the planking. Another rare one is the *P. Sulcata*. *P. striatula* is found at times in the soft stone under the planking. And so on for eleven or twelve species, some rare and some common; many confined to the planking, others distributed through all the beds. But the commonest of them is the *Patella rugosa*, which, when obtained south of Brinscomb valley, fully deserves its name; but north of the vale it loses much of its rough aspect, caused by the lines of growth, the striæ become faint, and the shell extremely thin. The aspect of the shell varies considerably, independent of the stages of growth,—some are more circular, and then the apex is more in the centre and less curved forwards; in others, which are oval, this apex is more depressed. When very young, the figure is more depressed, more oval, and nearly smooth, with the apex much twisted. The largest specimen known is $2\frac{1}{2}$ inches long, $2\frac{1}{4}$ inches broad, and 13 lines high. Another family represented largely at Minchinhampton is the Cylindritidæ (order *Opisthobranchiata*), of which I have obtained one specimen of a rare species, which is not confined to any bed, the *Cylindrites cuspidatus*. In this the shell is cylindrical, the spire small, the last whorl rounded at the upper edge, which rises as high as the one or two preceding ones, leaving their edges exposed.

The *Ostrea acuminata* is extremely abundant throughout the strata, especially in the fuller's-earth.

Of the *Lima impressa* few specimens, except those of the young, can be obtained perfect, most being extremely crushed;*

* I have been fortunate enough to obtain one specimen almost perfect.

the auricles are small, the shell moderately convex, but the longitudinal elevations are too slight to be considered costal.

Many species of the family of mytilus are found; one, rather rare, is the *Mytilus asper*, an elongated arched shell, striated longitudinally, the beaks small and slightly curved, the striæ numerous, furcated, and minutely imbricated. It occurs somewhat rarely in the shelly beds of the great oolite, and again in the marl beds of the inferior oolite near the hamlet of Nailsworth.

J. G. Grenfell, Esq., and the President complimented Wills on his excellent paper.

The President stated that the Archæological Society of Ireland had, at his request, granted this Society their Transanctions from 1870.

The election of eight members then took place. There were eleven candidates. The following were elected:—G. T. Bird, G Fulford, I. Routh, W. Stone, H. C. Jones, S. J. Douglas, H. Sumner, and H. C. Firth.

The President then stated that he had elected Batten a junior school member.

MEETING, February 16, 1872.

The second meeting for the term was held on Friday, February 16,—the President in the chair.

Forty-five members and visitors were present.

The President stated that he had elected T. K. Twiss and H. R. Carver junior school members; and that the Committee had elected A. Paul, Esq., O.C., an Honorary Member.

J. A. Gibbons then read a paper on 'The Roman Wall from Solway to the Tyne,' and exhibited many drawings.

MEETING, March 1, 1872.

The third meeting for the term was held on Friday, March 1,—the President in the chair. Forty-one members and visitors were present.

The President stated that the Committee had elected J. E. Jose, Esq., O.C., an Honorary Member.

Donations acknowledged :—A number of Coins, principally foreign, by A. Douglas ; Eggs of Barn-owl, Redbacked Shrike, Little Grebe, Parrot, Chiffchaff, House Martin, Swift, Kingfisher, Greenfinch, Lesser Whitethroat, and Lark, by H. Wills ; Lead and Copper Ores, by H. G. Richardson ; Polished Marble, by R. Donovan ; Polished Corals, by J. Gibbons ; Rulers made from the sub-fossil trunks of the yew and oak, found fifty feet below the alluvial soil, Cardiff, by A. Cruttwell, Esq., Corresponding Member; Skins of *Phalaropus lobatus*, *Tringa subaquatica*, *Strepsilas interpres*, *Tringa cametus*, *Hæmatopus ostrilegus*, *Tringa variabilis*, by M. Rickards, Esq., F.L.S. ; Gold in quartz from Australia, by J. E. Jose, O.C. ; Rev. J. Greene exhibited *Notodonta dictæoides* (Scotch form), and two Male Specimens of the rare *Cerura bicuspis*, which he had much pleasure in presenting to the Museum ; three pieces of French Paper Money, (1793), by Rev. F. Armitage.

S. J. Douglas then read a paper on 'Automata,' on which Messrs Greene, Gibbons, J. Stone, H. Stone, and Ward spoke.

MEETING, March 8, 1872.

The fourth meeting for the term was held on Friday, March 8,—the President in the chair. Fifty-three members and vistors present.

Donations acknowledged :—A Heron, by C. F. M'Niven, Esq., O.C. ; Provincial Tokens of the last century, from Bath, Salisbury, and Devizes, by J. Chitty ; Indian Elephant Molar Tooth, by G. Grant ; African Elephant Molar Tooth, by R. Donovan ; a Blind Worm (*Anguis fragilis*) in spirits, by C. Onslow.

The President announced that the Committee had elected Rev. J. Heyworth an Honorary Member.

The favourable criticism on Part ii. of the Transanctions in *Nature* for March 7 was then read by the President; also a letter from Professor Sedgwick, which, on the proposal of Rev. J. Greene, seconded by J. Allen, was ordered to be entered on the minutes.

In this letter Professor Sedgwick expresses a hope that he may be able to make himself acquainted with the proceedings of the

Clifton College Scientific Society, and proceeds thus:—'I have ever felt a great interest in Clifton, since I began my life as a practical geologist, for there I received my first lessons from my friend and fellow-labourer, the late Dean Conybeare, in the years 1819 and 1820. The beautiful scenery which surrounds Clifton still is a living picture in my mind's eye; and never can I forget the happy days I spent with Canon Guthrie and his admirable wife, the foundress of your chapel.

'May God continue to prosper your College which has flourished so nobly through the years of its early life.—I remain, dear Sir, very truly and gratefully yours, A. SEDGWICK.'

The Secretary then read a letter he had received from the Rev. Canon Kingsley, on the last number of the Transactions.

E. Crosse then read a paper (Part I.), on 'Glaciers,' exhibiting numerous photographs. J. G. Grenfell, Esq., spoke at length on the colour of the glaciers; the Rev. J. Greene, and Kent (visitor), also spoke.

W. Oliphant then read a paper on 'The Effect of Music on Animals.' Messrs Gibbons, Paul, Greene, Stone, Ward, Routh, and Stevenson spoke.

The Secretary read a letter from F. L. Penney, O.C., in which he stated that he wished to be elected a Corresponding Member. On the proposal of J. Stone, seconded by F. H. D. Powell, he was elected unanimously.

P. R. Ogle proposed, and G. Dakyns seconded, a vote of thanks to the President and Secretary for the manner in which they had edited the last number of the Society's Transactions: carried unanimously.

P. R. Ogle asked some questions respecting the accounts of the meetings of the Society that appear in the *Cliftonian*, and after some deliberation, the President proposed—'That the Secretary be authorised to furnish all accounts of the meetings of the Society for insertion in the *Cliftonian*, which accounts are not to be altered in any way by the editors of the *Cliftonian*, unless approved by the Secretary.' Seconded by P. R. Ogle, and carried unanimously.

The Committee brought forward the following motion:—'That for the future candidates for ordinary membership be elected by

the Committee.' This motion was seconded by Stevenson, and supported by Rev. J. Greene. P. R. Ogle brought forward an amendment, negativing the Committee's motion; this was seconded by J. Prinsep. Prinsep proposed, and Ogle seconded, that the debate be adjourned till the next meeting; this was carried.

MEETING, THURSDAY, MARCH 14, 1872.

An extraordinary meeting was held, Thursday, March 14, at two P.M.,—the President in the chair.

This meeting was called to discuss the motion of the Committee brought forward at the last meeting, respecting candidates for election. P. R. Ogle proposed his amendment negativing the motion. J. E. Prinsep proposed that the meeting be adjourned, seconded by Ogle; on putting it to the meeting the motion was lost. Prinsep then seconded Ogle's amendment. W. Wood and J. Stone spoke in favour of the Committee's motion.

Prinsep then rose to speak, but the President ruled that no person should speak more than once. On Messrs Ogle and Prinsep objecting, he further ruled that they, as proposer and seconder of the amendment, should have the privilege of addressing the meeting at the close of other members' remarks. J. A. Gibbons spoke in favour of the amendment; C. C. Stevenson and T. H. Warren for the motion. P. R. Ogle then began his remarks, but, as time pressed, the amendment was put to the vote—

For the amendment, . . .	8
Against, ...	20
Majority against, . . .	12

The motion of the Committee was therefore carried.

MEETING, FRIDAY, MARCH 15, 1872.

The fifth meeting of the term was held on Friday, March 15, in Big School.

The PRESIDENT in the Chair.

About 400 members and visitors were present.

The President introduced Mr Wm. Lant Carpenter, B.A., B. Sc., F.C.S., to the meeting, who at once began to deliver a lecture on

LIFE IN THE DEPTHS OF THE OCEAN.

The speaker commenced by referring to a short address on 'Deep-Sea Dredging' which he had delivered on the opening soirée of the Society's Museum and Library in June 1871, on which occasion a wish had been expressed that he would develop the subject at greater length.

Reverting to the subject of the evening, the popular title of which had been selected by the Society, he stated that the earliest instance in which living animals were brought up from great depths in the ocean was in the Arctic Expedition under Sir John Ross in 1818. Two or three other isolated instances were given, and attention was called to the opinion of the late Prof. Edward Forbes, which, though for a long time almost universally accepted, was founded upon insufficient data, viz., that no animal life existed at a greater depth than 300 fathoms (1800 feet). The facts which were occasionally observed, and found to be inconsistent with this theory, were attempted to be explained away, until the observations made by Dr Wallich in the sounding voyage of the *Bull-dog* in 1860, appeared to prove incontestably that animal life of many varieties did exist in the abyssal depths of the North Atlantic Ocean. In 1861, a telegraph cable in the Mediterranean being taken up for repairs, there were found attached to it, in portions submerged to a depth of 1500 fathoms, several living Mollusca. In 1866 and 1867, Professor Sars, of Christiania, had the opportunity, under the Norwegian Government, of dredging around that coast at various depths between 200 and 450 fathoms, and 427 species were thus collected. Some of these were of the highest scientific interest, being representatives of species and genera (*e.g.*, the Rhizocrinus) that were geologically extinct, while others were quite new. When these remarkable results were made known, application was made by the Royal Society to Her Majesty's Government for aid in prosecuting similar researches, which were beyond the reach of any private individual. This was granted, and in the years 1868 to 1871 inclusive, a series of researches were made in the North Atlantic and the Mediterranean, under the general superintendence of Dr W. B. Carpenter, Professor Wyville Thomson, and Mr J. Gwyn Jeffreys, the speaker having also been a member of two of these expeditions.

The general mode of operations was then described with the aid of diagrams. One of the most important was temperature sounding, the temperature of the sea at various depths being ascertained

by self-registering thermometers of a peculiar construction. In ordinary thermometers the pressure of the water (amounting to one ton per square inch for every 800 fathoms) compressed the bulb, and caused the instrument to register too high. This source of error was completely counteracted by surrounding the ordinary bulb with a second, the intervening space being partly filled with fluid. There was also attached to the sounding line an apparatus for collecting specimens of the water at any desired depth. These instruments, and the deep-sea sounding apparatus, by which the exceedingly heavy weight used in sounding was detached at the bottom, were described in detail. The dredging was carried on by a dredge of the ordinary 'naturalists'' form, made *very much* heavier, the rope employed being the best Chatham 'hawser laid' 2¼-inch rope, of which 3000 fathoms were kept in coils for use on deck, and wound in when required by a donkey engine.* Sounding and dredging had been carried on successfully at all depths down to 2435 fathoms, this being as great a depth below the surface of the sea as the summit of Mount Blanc is above it, and the pressure at this point exceeding three tons per square inch.

The speaker then stated some of the results which had been obtained.

It had been most conclusively demonstrated that the notion of bathymetrical zones of animal life was entirely erroneous, and that animal life of the highest invertebrate types existed at all depths. The habitats of particular animals had been shown to depend upon temperature, and not upon depth. The range of geographical distribution of many species had been enormously increased; a vast number of new ones had been added to the list; and several species, hitherto supposed to have become extinct, had been discovered alive. A discussion of the physical results, and especially of the thermometric observations, would have occupied a whole lecture; but it was stated broadly, that the temperature of the North Atlantic diminished with the depth, though not in proportion to it; and that there was reason to believe that the source of the vast body of water at and below 36° Fah., which occupied the lower part of the North Atlantic basin, was a submarine polar current, and that an interchange of polar and equatorial water took place by a movement near the surface from

* An important addition to the dredge, suggested by Captain Calver, R.N., who commanded H.M.S. *Porcupine* in the 1869 and 1870 expeditions, was found extremely serviceable. Long projecting rods of iron were attached to the dredge rope, at right angles to it, just above the dredge. To the ends of these, bundles of spun-yarn were attached, which swept the bottom of the sea, and in the hempen tangles of which many animals were secured.

the equator towards the poles, and near the bottom from the poles towards the equator. In the Mediterranean, however, which was cut off by its position from the general oceanic circulation, the temperature at all depths between 200 and 1700 fathoms was 55° Fah., and the bottom was almost destitute of any kind of life. No evidence of vegetable life had been found at any of the depths examined in the Atlantic.

The following were some of the instances given in support of the above general assertions. On the sea bottom between the north of Scotland, the Faroes, and the Shetlands, two very different deep-sea climates were found to co-exist. In the so-called 'warm area' the bottom temperature was 42½° Fah., at the depth of 650 fathoms, while the animal life found there corresponded closely in its general features to that found at corresponding temperatures in other parts of the North Atlantic. In the 'cold area,' however, at the same depth, the bottom temperature was 29½° Fah., and fauna of a semi-Arctic character were found, while the general character of the bottom, instead of being composed of the 'Globigerina mud' found in the warmer area, was largely made up of fragments of volcanic minerals, probably brought down by the cold current from Iceland and Jan Meyen. A sail of ten miles or less over the surface of the sea, was sufficient to cross from the warm to the cold area.

As prominent examples of new species discovered in these expeditions, the siliceous sponge (*Holtenia Carpenteri*) and a new large Pentacrinus were mentioned; and a description was given of a remarkable haul of the dredge at a depth of 994 fathoms off the Portuguese coast, containing 186 species of shells, of which 91 were recent, but chiefly northern forms; 24 were fossil, chiefly corresponding to those in the Sicilian tertiary beds, while 71 (or nearly 40 per cent.) were new or undescribed, some even representing new genera.

A description was then given, illustrated by diagrams, of some of the animals found during the deep-sea dredgings, especially of the siliceous sponges, and of several kinds of Foraminifera, some of which had siliceous, or rather arenaceous shells, and others calcareous. Of the latter, far the most abundant was the Globigerina, broken fragments and living specimens of which formed the basis of the Atlantic mud, which was found everywhere except in the 'cold area.' Globigerinæ formed also the chief constituent of chalk, and it was pointed out that, since no change of level as great as the present depth of the Atlantic (12,000 feet and upwards) had taken place since the deposit of the Chalk formation, there was reason to believe that the deposit now going on in the North Atlantic was continuous with that which was being formed there at the time of

the deposition of the Chalk. This view was supported by the discovery of living representatives of the Chalk fossils.

The general question of the conditions of existence of animal life in the abyssal depths was then discussed. It was pointed out that, although the pressure of the water was so enormous, it was *equal in all directions*, and that the water permeated the entire bodies of all the animals (none of them possessing any air sacs), so that it was fair to infer that the pressure was not felt, just as the 14 lb. per square inch atmospheric pressure on the human body is not perceptible. The power of some marine worms to endure a pressure in water of three tons to the square inch, had been submitted to the test of direct experiment in a hydraulic press, and the animals were uninjured. The conditions of their respiration were then alluded to. The speaker stated that it had been a part of his duty to analyse the specimens of abyssal water for the gases dissolved in it. The general result of a long series of analyses showed that there existed close to the bottom of the sea a very large percentage of dissolved carbonic acid (amounting to 60 per cent. of the total gaseous constituents in some instances), while the proportion in surface water rarely exceeded 25 per cent. The quantity of this gas appeared to vary with the abundance of animal life, and was also greater in southern than in northern waters. It was also pointed out that many of the lowest kinds of animals living on the sea-bottom probably absorbed their food from a state of solution in the water through the general surface of their bodies; and some of the speaker's researches had tended to confirm this view, since they demonstrated the existence of organic matter in the oceanic depths in a state easy to be assimilated—a sort of diluted protoplasm, in fact. The question of the penetration of light to the sea-bottom was touched upon, and the probability of its reaching thus far was supported by the fact that the higher kinds of animals dredged up from even the greatest depths, were furnished with eyes, and endowed with the most brilliant tints.

In conclusion, the lecturer said that it had been his wish to stimulate thought and inquiry upon this and kindred subjects.

The lecture was illustrated with numerous diagrams, lent for the occasion by Dr W. B. Carpenter, F.R.S., of the University of London.

At the close of the lecture the Rev. Prebendary Percival thanked Mr Carpenter, in the name of the meeting, for the very interesting and suggestive lecture they had just heard from him. Mr Carpenter, in acknowledging the compliment, said that if the lecture

had been at all a suggestive one, and likely to lead any of the audience to inquire more deeply into the matters he had briefly touched upon, his purpose was served, and he was amply repaid for any trouble incurred in preparing it.

The meeting was then adjourned.

MEETING, Thursday, March 21, 1872.

An extraordinary meeting was held on Thursday, March 21,—the President in the chair.

The meeting had been called at the desire of J. Prinsep, to reconsider the motion relating to the election of members, passed on March 14. Prinsep's motion for re-discussing the measure being carried, the President stated that he thought the Committee should nominate candidates, while the Society should elect them. The Rev. J. Greene said that he should like the Society to elect half and the Committee the other half. J. G. Grenfell, Esq., then brought forward a motion to that effect, which was seconded by J. Prinsep. W. Wood proposed that the Committee nominate candidates, half to be elected by the Society, and half by the Committee. The Rev. J. Greene opposed Wood's motion, and proposed that the meeting be adjourned till Friday. The meeting was then adjourned. There was no meeting on Friday.

MEETING, Friday, March 29, 1872.

The sixth meeting for the term was held on March 29,—the Rev. E. Harris in the chair, who read a letter from the President, explaining the cause of his absence.

E. Crosse then read the second part of his paper on 'Glaciers.' On this paper Rev. E. Harris spoke. J. Allen proposed, and J. E. Locke seconded, a vote of thanks to E. Crosse for his paper. The motion was carried unanimously.

J. I. Routh next read a paper on 'Animal Magnetism.'

MEETING, FRIDAY, APRIL 5, 1872.

The seventh and last meeting for the term was held on Friday, April 5. Thirty-four members present.

The PRESIDENT in the chair.

G. Dakyns proposed that the Committee do elect the ordinary members of the Society, seconded by T. L. Jenkins. J. A. Gibbons proposed as an amendment, that half of the votes be given to the Society and half to the Committee; seconded by F Powell.

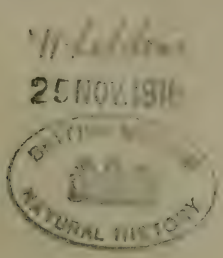
For the amendment, . . .	10
Against, ...	16
Majority against, . . .	6

The motion of the Committee was therefore carried.

J. E. Jose, Esq., O.C., Honorary Member, then gave some information on archæology, and a list of places near Bristol worth visiting. On the motion of the President, J. E. Jose was elected Director of the Archæological Section. The monetary accounts of the Society were then read by the Treasurer.

The Society next proceeded to elect officers for next term :—For the office of Treasurer J. Allen was elected; for the Committee, J. F. M. Stone, D. Pearce, R. B. Don, W. Oliphant, and T. H. Warren were elected.

At a subsequent Committee meeting, J. F. Stone was elected Secretary to the Society.



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TRANSACTIONS

OF

THE CLIFTON COLLEGE

Scientific Society

FOUNDED JUNE 25, 1869

"VIRESQUE ACQUIRIT EUNDO."—Virg. *Æn.* iv. 175

PART IV.

CLIFTON
J. BAKER & SON, MALL PLACE
T. KERSLAKE & CO., ROYAL PROMENADE
AND AT THE SECRETARY'S OFFICE, CLIFTON COLLEGE
1873

PRICE EIGHTEENPENCE.

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BRITISH MUSEUM
NATURAL HISTORY

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PREFACE.

In issuing the Fourth Part of our Transactions, we are glad to be able to say that our Society continues to prosper. In the summer and autumn terms of last year there was a falling off in the attendance at the meetings, but this term the meetings have been crowded almost to excess. We still, however, like most school societies, have to deplore the want of real workers at Natural History. Except in Geology, very little has been done. This, however, is partly due to the fact that no one had been appointed to the post of Natural History Master, in the place of Mr Barrington-Ward. As this vacancy has now been filled, we hope to see a revival of interest in Botany.

The thanks of the Society are due to many friends who have helped us in various ways. To Mr W. W. Stoddart we are indebted for a most interesting lecture on spiders. Amongst the many donors of specimens to our College Museum we must specially mention the following:—Rev. J. Greene, J. G. Grenfell, Esq., J. A. Gibbons, C. H. Firth, E. W. Carus-Wilson, A. Cole-Hamilton.

J. G. G. J. D.
G. D. A. E. D.
J. A. R. M. J.

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Wells, G. C.
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Younghusband, A.

RULES.

I.—That this Society be called the 'CLIFTON COLLEGE SCIENTIFIC SOCIETY.'

Constitution.

II.—That the Society consist of Ordinary, Corresponding, and Honorary Members.

Officers.

III.—That the Officers of the Society consist of a President, Secretary, Treasurer, and five Members of Committee, to be elected from and by Members of the Society, with the exception of the Secretary, who shall be chosen by the Committee from their own number. All Officers, excepting the President, to be elected terminally.

Management.

IV.—That the affairs of the Society shall be conducted by the above Officers.

Secretary.

V.—That the duties of the Secretary be, to keep a list of all the Members of the Society, and of all former Members and Benefactors, who may wish to receive the Transactions of the Society; to give notice of meetings, and to keep a detailed report of the proceedings, as well as lists of Members and Visitors present at each meeting. In the absence of the Secretary, the President may appoint any Member of the Committee to take minutes of the proceedings.

Treasurer.

VI.—That the duties of the Treasurer be, to collect all sums of money due to the Society, to receive all donations of money, and to disburse all sums of money payable by the Society out of the funds intrusted to him.

That the Treasurer furnish terminally a detailed account of the receipts and disbursements, to be audited by the Committee.

Members.

VII.—That the number of Members be seventy, of whom ten shall be elected from the Junior School.

That Honorary Members be elected by the Committee, for two years only; but any Honorary Member re-elected after that period, be not required to pay any further subscription.

That Honorary Members, on the payment of the single sum of one guinea, or the annual sum of five shillings, shall receive the Transactions, post free.

That Corresponding Members be elected by the Society for five years; but that a Corresponding Member, on signifying to the Secretary in writing his desire to remain on the Society's books at the termination of that period, be allowed to do so.

That Ordinary Members be elected by the Committee.

That, on election, every Member of the Society shall sign his name in a Register (to be kept by the Secretary).

That a subscription be payable terminally by all Ordinary Members (the amount to be fixed by the Committee), but in no case to exceed Two Shillings and Sixpence for the Upper, and Two Shillings for the Junior School.

That Honorary Members residing at the College shall have all the privileges of Ordinary Members.

That all subscriptions must be paid between the first and second meetings of the term, and that any Member retiring from the Society be required to pay all subscriptions due.

That, under penalty of expulsion from the Society, all Ordinary Members be required to attend two-thirds of the meetings in each term, except for reasons deemed sufficient by the President.

That Corresponding Members shall have the privilege of taking part in the proceedings of all meetings that they may attend, but shall not be liable to any subscription.

Sections.

VIII.—That Sections be formed for the more accurate study of the different branches of science, and that the Directors of these Sections be chosen terminally by the Society.

That the Sections shall hold meetings as often as may seem fit to their respective Directors, at which any Members of the College, with the sanction of the Director, may attend.

That the Directors of the different Sections be invited to communicate to the Society any matters of interest which may have come before them, and that such communications be made at the commencement of each public meeting, at least one day's notice having been given to the Secretary.

That reports of the work done in each Section shall be handed by the Directors to the President before the final meeting of every term.

That the President and Secretary be *ex officio* Members of every Section, and shall receive notice of all sectional meetings.

That not more than ten Members be permitted to join any one Section.

That all elections in each of the Sections be vested in its Director, who may, at his discretion, remove any Member from it, subject only to the approval of the President.

That there shall be six Sections: BOTANY, ZOOLOGY, CHEMISTRY and PHYSICS, ENTOMOLOGY, GEOLOGY, and ARCHÆOLOGY.

Meetings.

IX.—That ordinary Meetings of the Society be held at least once a fortnight during term, but that the President be empowered to call extraordinary meetings and to postpone the regular meetings.

That fifteen Members shall form a quorum.

That the order of business at each meeting shall be arranged by the President.

That Members be requested to bring for exhibition at the meetings of the Society specimens of Natural History, and illustrations of Natural and Physical Science in general.

That Members be invited, when they may have it in their power, to present donations and specimens to the College Museum, such donations to be acknowledged at the meetings, and in the Society's Transactions.

That in all cases of equality in voting, the President shall have a casting vote.

New Rules.

X.—That any Member of the Society have power to propose any new rule, or any alteration in an old one, provided the motion be seconded by another Member, and that notice of at least one week be given to the Secretary.

Excursions.

XI.—That two Excursions be made every three weeks for the purpose of studying Natural History. That Members of the College, not in the Society, be allowed to attend on obtaining permission from the President; the number thus admitted not to exceed eight.

That all Members of the Society below the sixth form, who have not otherwise taken an active part in the business of the Society, be obliged to attend two Excursions in every term, under penalty of surrendering their places in the Society to qualified candidates.

TRANSACTIONS

OF THE

CLIFTON COLLEGE SCIENTIFIC SOCIETY.

SECOND TERM, 1872.

MEETING, May 3, 1872.

The first meeting for the term was held on Friday, May 3d, in the Physical Lecture-room.

The President in the Chair.

Forty members and visitors were present.

The following donations were acknowledged:—Recent Corals and fine Beak of Sword-fish (*Xiphias gladius*), and large Ammonite, by Mr Webb; Jaw and Teeth of Shark (*Myliobates*), by G. Grant, Esq.; Box of Minerals, by J. Cocks, Esq., Falmouth; some Skins of uncommon English Birds, by W. H. Leach (O.C.); Petrifactions, by J. A. Gibbons.

The President announced that R. Donovan, C. Donovan, H. Darling, and H. Grant had been elected Junior School Members.

The election of Directors of Sections then occupied the meeting.

The following candidates were proposed by the Committee:—

Archæology, . . .	J. E. Jose, O.C.
Zoology, ...	D. Pearce.
Chemistry, . . .	P. R. Ogle.
Entomology, . . .	J. Stone.
Botany, ...	P. R. Ogle.
Geology, ...	J. G. Grenfell, Esq.
Physics, ...	W. A. Smith.

The candidates proposed by the Committee were duly elected.

The President (M. J. Barrington-Ward, Esq.) next, in a speech, tendered his resignation to the Society, owing to his recent appointment as one of Her Majesty's Inspectors of Schools. J. Stone being then moved into the chair for the time, T. H. Warren addressed the meeting in terms regretting the loss of Mr Ward, and proposed the following address :—

'The members of the Clifton College Scientific Society desire to place on record their sense of the obligations which they are under to Mr Barrington-Ward. They offer him many thanks for the energy, ability, and self-devotion which he has displayed in managing the business of the Society. They trust that he will long continue to maintain his interest in and connection with the Society, and they heartily wish him success and happiness in his new career.'

The address was seconded by W. J. P. Wood, and carried with acclamation. Mr Ward thanked the Society for the address in a short speech. The Rev. J. Greene then proposed J. G. Grenfell, Esq., as the new President. The nomination was seconded by D. Pearce, and carried unanimously.

Mr Ward then conducted the President to the chair, where he thanked the Society for electing him President.

The Secretary stated that the subscription for the term was 2s. 6d. for the College, and 2s. for the Junior School.

MEETING, May 10, 1872.

The President (J. G. Grenfell, Esq.) in the Chair.

The second meeting for the term was held on Friday, May 10, in the Physics Lecture-room.

The following address to Mr Ward, drawn up by the Committee, was read and proposed by the President, seconded by F. H. D. Powell, and carried unanimously :—

'To M. J. Barrington-Ward, Esq., B.A., late
Assistant-Master at Clifton College.

'Dear Sir,—We, the members of the Clifton College Scientific Society, wish to express our sincere regret at your leaving us.

Since your election as President in 1870, the Society has flourished beyond the expectations of the most sanguine. You leave us now with the satisfaction of knowing that it was during your presidency that our Society gradually attained its present vigorous state, and that from the lowest ranks of Public School Scientific Societies it has now taken its stand among the highest, a position which we trust it will ever maintain. You, sir, have been, under every change of circumstances, a firm and enthusiastic friend and most able President of our Society. We thank you most cordially for all that you have done for us. We feel sure that you will always take a lively interest in Clifton College and its Scientific Society, and we trust that your connection with us as an honorary member may long continue. We congratulate you on your appointment as one of Her Majesty's Inspectors of Schools, and wish you every success and happiness in your new sphere of duty.'

(The address was afterwards signed by every member of the Society, and sent to Mr Ward.)

P. R. Ogle proposed, and Mr Stone seconded,

'That for the future an account of every important meeting of the Society be drawn up and sent for insertion in the local papers, as soon after each important meeting as possible.'

This motion was carried, and the Secretary was asked to furnish the accounts.

MEETING, May 17, 1872.

The President in the Chair.

The third meeting for the term was held on Friday, May 17, in the Physical Lecture-room. Fifty members and visitors were present.

The following donations were acknowledged: — Skeletons of Perch (*Perca fluviatilis*), Pike's Head (*Esox lucius*), Pigeon, Snake, and Toad (*Bufo vulgaris*), by Dakyns's House, for which the thanks of the Society were given. The President expressed a hope that other houses would follow the good example set by Dakyns's House. Also, a collection of dried Ferns, by Fuller; some Birds' Nests, by Howse; Head of Trilobite, by C. H. Frith; and Fossils, by J. G. Grenfell, Esq.

The President announced that the Committee had elected F. L. Peck and T. R. Montgomery members of the Society.

The President then delivered an address, alluding to the objects of the Society, and the manner in which he wished these to be carried out. He next read the following paper on

STREPTORHYNCUS KELLII.

M'Coy.

The shells which I now pass round were found in the quarry at the foot of the gully leading down to the river from the Downs. The rock is Oolitic limestone, and belongs to the lower portion of the Carboniferous limestone, but above the Black Rock. These specimens, and one of them in particular, are important, as settling a disputed point between Davidson, author of the 'Monograph on British Carboniferous Brachiopods,' and Professor M'Coy. They belong to the genus Streptorhyncus, of the class of Brachiopods. *Streptorhyncus crenistria* is a very common shell in the Carboniferous or Mountain limestone, and is thus described by Davidson:—'Very variable in shape; hinge-line straight, slightly exceeding or somewhat shorter than the greatest width of the shell; cardinal angles rounded or prolonged, with acute terminations; ventral valve variable in its curves, flat in middle, or more or less convex throughout; dorsal valve moderately or extremely convex; surface of both valves covered with numerous strong, radiating, rounded striæ, with flattened interspaces of variable width, the ribs and interspaces being at the same time intersected by fine concentric lines, giving to the longitudinal ones a crenulated appearance. Dimensions very variable.' You will observe that the shape, length of hinge-line, cardinal angles, curvature of valves, fineness of ribs, and size are all variable in undoubted specimens of *Streptorhyncus crenistria*.

Professor M'Coy made a new species of certain shells of this genus which are found at Clifton in the Black Rock, in Scotland and Ireland, and which he named *Streptorhyncus Kellii*. It differs from the former in these respects:—

1. Presence of deep, rounded mesial furrow.
2. Cardinal angles always rounded.
3. The ribs are finer and closer, though he says this character is not of much value.
4. Smaller in size, never exceeding two inches in length.
5. More convex. He lays most stress on the first two of these differences.

Davidson, who wrote after M'Coy, remarks that the three latter differences are unimportant, considering how much *S. crenistria* varies in these respects. You will easily see this in the specimens from the Black Rock, one very small one having very acute cardinal angles.

With regard to the second point, he shows that *S. crenistria* has its angles sometimes acute, sometimes rounded, as you will see by comparing the sketches and specimens from the Black Rock. Still no specimen had as yet been found with the mesial furrow, and also with its cardinal angles acute; so although he thinks *S. Kellii* is only a variety of *Crenistria*, he leaves the question open, putting a note of interrogation after the words 'this species or variety.'

The shell marked No. 3 supplies this want; it has the furrow and also the acute angles. There is then only the furrow left. The specimens from the gully vary very much in the depth of this furrow, and in some it is almost obliterated. These shells then form the connecting links between *Kellii* and *Crenistria*, and we may safely conclude that the former is only a variety and not a separate species.

The PRESIDENT then read the following paper on the Lower portion of the

LOWER LIMESTONE SHALES, CLIFTON.

The Carboniferous Limestone near Bristol, as exposed in the section of the river Avon, is separated from the Devonian or Old Red Sandstone by a series of beds of shale alternating with thin bands of limestone. The Carboniferous Limestone extends from the St Vincent Rocks to the Black Rock, and the shales extend as far as Cook's Folly, where they are replaced by beds of dark red sandstones, grits, and marls. The thickness of the limestone is given as about 1450, and that of the shales as 500 feet. Towards the lower part of the shales is the celebrated Clifton bone bed, which is full of coprolites, and contains many fish teeth.

This bed is rather more than 100 feet above the Old Red Sandstone. It was at one time looked upon as the base of the Lower Limestone shales. In the first volume of the Geological Society's Memoirs is a detailed description of the Avon section, including these beds, by Mr Williams of the Geological Survey. He found fossils in only one bed below the bone bed, at a distance of about 56 feet from it. Mr Stoddart subsequently found that some beds immediately below the bone bed were composed mainly of fossils called Bryozoa, and a little further down, 24 feet below the bone

bed, he found a bed containing marine shells of the species *Modiola Macadami*, and other fossils. These beds were exposed on the old line of railway to Avonmouth.

The new railway is being cut above the old one, and an excellent section is afforded. Mr Williams' list is of no use for this section, as it is impossible to identify his beds. I therefore made the following list with careful measurements, and in so doing found fossils in many beds not previously described as fossiliferous.

Mr Sanders, who made the well-known map of this district, went on the principle that the Lower Limestone shales extend as far downward as there are Carboniferous fossils to be found, and he called the beds below Mr Williams' bed Passage beds, leaving it uncertain whether they belonged to the Old Red Sandstone formation or to the Carboniferous. The result, then, of this examination has been to draw the line sharper between the two formations, and to get rid of some of this debatable land. The Modiola has been found as far down as 104 feet below the bone bed, leaving only about 20 feet to be disputed. It is possible that a closer examination will still further diminish the gap.

There is another question, however, of great interest connected with these beds. In Ireland the thickness of the beds between the Carboniferous Limestone and the Old Red Sandstone, instead of being only 500 feet as here, amounts to 5000 feet, and must have taken thousands of years to deposit. They are divisible into two main groups of 2000 and 3000 feet respectively, characterised by their own peculiar fossils.

The lower group, 3000 feet thick, is called the Coomhola grits.

At Marwood, near Barnstaple, North Devon, are found sandstones, yellow, brown, and red, with plants and marine shells, some of which are common to the Carboniferous rocks, others are Devonian. It has been disputed whether they should be reckoned Carboniferous or Devonian.

Mr Stoddart has shown (Report of British Association for 1864) that these Clifton beds correspond with the Coomhola grits, and he maintains that they also correspond with the Marwood beds, because a certain number of the fossils are identical. By increasing the list of fossils, we may work out this parallelism in greater detail. At present the Marwood sandstones are classified as Devonian, not as Carboniferous; whilst the Coomhola grits are considered to be Carboniferous. The question also arises, how far the lower sandy portion of these beds corresponds with the Glengariff grits and other beds in Ireland which lie below the Coomhola grits, and which are reckoned as Devonian. Great interest, therefore, attaches to the fossils and beds in the following list.

The most interesting results at present obtained as regards fossils are :—

1. Modiolæ being traced all through down to 104 feet below the bone bed.
2. The abundance of Athyris Roysii in Nos. 33 and 40.
3. The assemblage of fossils in No. 57.
4. The Spirorbis Helicteres or Serpula scalaris (?) in No. 81.
5. Spirifera, Lingula, and other shells in No. 113.
6. The Lepidodendron and other plants in beds 135 to 138.

List of beds forming the lower part of the Lower Limestone shales, from the bone bed to the Old Red Sandstone. Measured on the upper line of railway to Avonmouth. The figures in brackets give the depth *below* the bone bed.

		Inches.	
	Bone bed—Principal fossils,	4 to 6	
		Ft.	In.
	Fenestella, two or three species, Ceriopora rhombifera, Spirifera bisulcata, Spirifera glabra, Discina nitida, Lingula mytiloides, Conularia quadrisulcata, Cladodus conicus, Chomatodus linearis, Ctenacanthus tenuistratus, Helodus levissimus, Psammodus porosus, Coprolites,		
1.	Green marl,	0	2
2.	Reddish gray limestone,	3	0
3.	Red limestone, aluminous at top. Bryozoa abundant in non-aluminous part. 1,600,000 perfect fossils, besides debris, in 1 lb. avoirdupois weight. The fossils are composed of silicate of iron, and are easily obtained by dissolving the matrix in dilute hydrochloric acid. About one-third are composed of Bryozoa. Greater portion of remainder encrinital ossicula; a few pelvic plates of Poteriocrinus; numerous casts of two species of Entomostraca. Fossils—Poteriocrinus, Platycrinus, Cythere ovalis (new species), Cytherella lunata (new species), Ceriopora rhombifera (*Goldf.*), Pleurotomaria pygmæa (new species), Euomphalus triangulatus, Natica plicistria (*Young*). Productus, one specimen. Psammodus porosus, one tooth, small fish spine. In the aluminous portion at top are many small Bryozoa; the encrinites have almost disappeared,	8	6
4.	Red limestone, [15 2]	3	6
5.	Shale parting,	0	1
6.	Red limestone—2 beds, [19 0]	3	9
7.	Shale parting—variable,	0	2
8.	Red limestone,	1	11
9.	Shale parting,	0	1
10.	Red limestone,	1	0
11.	Shale, green and red,	0	1
12.	Red limestone, [22 9]	0	6
13.	Shale,	0	1
14.	Greenish limestone—2 or 3 beds,	0	4
15.	Red shale,	0	4
16.	Thin limestone—3 beds, [23 10]	0	4

	Ft.	In.	Ft.	In.
17. Green shaly marl, Modiola Macadami, Avicula Damnoniensis, Natica plicistria, Spirorbis omphalodes, Cypridina Scotoburdigalensis, Cypridina subrectus, Knorria dichotoma,			1	6
18. Marly green limestone,	[25	7]	0	3
19. Red limestone,			3	6
20. Impure flaky limestone,			0	7
21. Greenish limestone,			0	6
22. Red marl, with limestone masses,			1	2
23. Aluminous limestone, gray,			0	6
24. Red marly limestone,			0	6
25. Impure grayish-brown limestone shale—3 or 4 beds,			1	0
26. Green marl, thick bedded,			2	4
27. Impure grayish limestone,			0	4
28. Green shale,			0	2
29. Impure dark gray limestone,			0	4
In beds corresponding to 27, 28, 29, Modiola Macadami and Spirorbis.				
30. Green shale, thin,	[38	6]	2	0
31. Blue limestone—2 beds. Entomostraca abundant, small Euomphalus, plants, fragment of larger shell,			0	11
32. Green shale, thin,			2	0
33. Blue limestone. Athyris Roysii and Bryozoa,			0	3
34. Yellowish-green calcareous shale,			1	3
35. Aluminous limestone,			0	2
36. Shale,			0	1
37. Limestone—2 beds,			0	5
38. Shale,			0	1
39. Compact dark limestone—2 beds,			0	3
40. Brown shale. Athyris Roysii abundant, Modiola Macadami, and plants,	[45	0]	1	1
41. Limestone, dark. Athyris Roysii, Retzia radialis, Ceriopora rhomboidea,			0	3
42. Yellow and green shale,			1	0
43. Limestone—2 beds. Entomostraca,			0	6
44. Compact dark bluish-gray shale. Modiola, Entomostraca and Euomphalus neglectus (?) in corresponding bed, now removed.			4	8
45. Impure light green limestone,			0	8
46. Pale green concretionary marl,			3	8
47. Impure limestone,			0	3
48. Dark green and gray shale,	[57	4]	1	4
49. Brown crystalline limestone. Bryozoa and Retzia radialis,	[60	6]	3	2
50. Green shale,			0	1½
51. Brown limestone, granular,			0	1½
52. Green and brown shale,			1	1
53. Purple limestone,			0	2
54. Brown shale,			0	2
55. Blue limestone—interrupted—merging in shale above. Bryozoa and shells,			0	6
56. Dark shales,			1	0
57. Encrinital dark limestone. Streptorhyncus, Spirifera, Retzia, Bryozoa,			0	3

		Ft.	In.	Ft.	In.
58.	Soft brown shale, with a *little* limestone here and there,			0	8
59.	Compact purplish marl. Modiola,			0	7
60.	Purplish shale, almost passing into limestone in parts,	[65	5]	0	3
61.	Brown shale, with concretions of limestone forming irregular lines in middle,			1	2
62.	Dark gray limestone, with Modiola (?) and Spirorbis,			0	1½
63.	Brown shale,			0	3
64.	Limestone, variable. Bryozoa (?), Conchifers, and Spirorbis,			0	4
65.	Brown shale,			0	3
66.	Compact dark limestone,			0	3
67.	Brown shale,			0	2
68.	Impure dark limestone,			0	2
69.	Brown shale,			0	5
70.	Darker shale,			0	9
71.	Bituminous dark purple shale. Plants, Modiola,			0	5
72.	Dark shale,			0	3
73.	Dark limestone, variable,			0	3
74.	Brown shale, Modiola,	[70	9]	0	7
75.	Limestone—2 beds, impure,			1	0
76.	Limestone, purplish. Entomostraca,			0	7
77.	Shale parting,			0	1
78.	Dark gray and brown compact limestone. Plant, Entomostraca (?)			0	9
79.	Shale parting,			0	1
80.	Limestone,	[73	6]	0	3
81.	Gray shale, with thin strings of limestone. Modiola, Spirorbis Helicteres, or Serpula scalaris (?), Spirorbis globosa,	[75	6]	2	0
82.	Gray limestone, marked in layers,			0	4
83.	Pale shale,			0	1
84.	Bluish-gray limestone, flaky,			0	1½
85.	Shale,			0	½
86.	Same limestone, shell,			0	2
87.	Shale, pale,			0	3
88.	Gray limestone, compact,			0	5
89.	Pale shale,			0	1
90.	Whitish flaky limestone,			0	2
91.	Shale,			0	¼
92.	Brown limestone,			0	2½
93.	Shale,			0	1
94.	Blue limestone,			0	8
95.	Yellowish shale, with plants,			0	½
96.	Blue limestone, compact,	[79	11]	1	0
97.	Sandy shale,			0	2
98.	Dark blue limestone,			0	4
99.	Shale,			0	1
100. 101.	Blue limestone. Terebratula Hastata, or Modiola, 2 beds,			0	6
102.	Impure limestone,			0	7
103.	Yellow shale,			0	½
104.	Dark limestone,			0	8
105.	Dark brown shale,			0	5

		Ft.	In.	Ft.	In.
106.	Dark brown shale, with limestone concretions,			0	4
107.	Gray limestone. Shells (?) at top, about			0	10
108.	Shales,			0	5
109.	Flaky limestone,			0	2½
110.	Gray shales,			1	7
111.	Impure limestone. Serpulites (?), Entomostraca, abt.	[87	8]	1	7
112.	Yellow and green shale,			0	5
113.	Yellow and green shale. Plants at top—Knorria dichotoma, Lingula, Modiola, Aviculoid shell, Spirifera, fish scale,			1	3
114.	Blue limestone,			0	6
115.	Shale, sandy,			0	3
116.	Limestone, dark gray,			0	4
117.	Shale, sandy. Plants,			0	4
118.	Shale, sandy. Dendritic manganese,			0	1
119.	Limestone, impure, dark,			1	6
120.	Limestone, gray, sandy,	[92	6]	0	2½
121.	Marl, pale. Arenaceous (?),			0	5
122.	Shale, bluish-gray,			0	11
123.	Interrupted band of limestone,			0	2½
124.	Gray shale,			0	1½
125.	Interrupted band of limestone—lowest limestone,	[94	4]	0	2
126.	Gray shale,			0	3
127.	Yellowish-brown shale,			0	9
128. 129.	Gray marly shale, alternating with yellow marl. Modiola, about 2 feet from top; plants at bottom,	[102	7]	7	3
130.	Yellow calcareous shale, variable,			0	9
131.	Yellow marly shale,			1	7
132.	Gray shale, dark,	[105	11]	1	0
133.	Gray sandstone,			0	8
134.	Gray shale—carbonaceous in parts. Plants,			0	10
135.	Sandstone, pale—micaceous. Many plants,			0	3
136.	Gray shale. Plants, Lepododendron,			0	5
137.	Pale sandstone,	[109	1]	1	2
138.	Gray shale—in part red. Plants,			2	6
139.	Sandstone, pale—highly micaceous, flaggy,			1	0
140.	Pale green sandy shale,			0	1
141.	Sandstone, with parting,			0	5
142.	Gray sandy shale, passing into sandstone—in parts yellow and red, and with marly fracture,	[115	4]	2	3
143.	Red marl,			0	6
144.	Mottled red and green sandy marl, chiefly red,			8	0
145.	Gray sandstone—2 beds,			1	0
146.	Red marl, with 2 sandy green beds,			4	6
147.	Gray sandstone,	[130	4]	1	0
148.	Red sandstone, with quartz pebbles,			1	9

This conglomerate bed is adopted as the top bed of the Old Red Sandstone. It is a question whether the division might not be made at No. 143.

To facilitate reference, these beds are grouped as follows:—

Nos.		Ft.	In.
1–12.	Red limestone—thick bedded,	22	9
13–18.	Thin limestone and shale,	2	10

Nos.		Ft.	In.
19.	Thick limestone—1 bed,	3	6
20– 48.	Brown and green shales, and thin blue limestone—paler shales at bottom,	28	3
49.	Thick bed of limestone,	3	2
50– 74.	Brown shales, with a dark purple bed at base,	10	3
75– 80.	Limestone—4 beds,	2	9
81.	Shales,	2	0
82–120.	Limestone and shale—4 larger limestone beds,	17	0
121–132.	Shales, gray and yellow,	13	5
133–137.	Sandstone, pale,	3	4
138.	Shale, gray,	2	6
139–142.	Gray sandstone and shale,	2	9
143–144.	Red marl,	8	6

These beds appear to thin out rapidly along the strike to the S.W. Mr Williams, who measured this portion on the Somersetshire side of the river, makes the total thickness from the bone bed to the first red marl bed 86 feet, while this section gives 115 feet. The railway cutting was made narrow at first, and then cut back about 12 feet. In this distance the thickness of the beds, Nos. 1 to 48, increased from 52 feet 6 inches to 57 feet 4 inches.

In reference to the former part of the address, the President brought forward the following motion :—

'That two excursions be made every three weeks, for the purpose of studying Natural History, open to the whole school. A list of those joining each excursion to be taken by the member of the College who is highest in the school, such lists to be entered in a book kept for that purpose by the Secretary. That all members below sixth form of the Society, or who have not otherwise taken an active part in the business of the Society, be obliged to attend two excursions in every term, under penalty of surrendering their places in the Society to more qualified candidates. Notice of excursions to be given by the President.'

P. Ogle proposed, and W. Wood seconded, that each clause of the motion be put to the meeting separately. This was carried, and the President proposed 'That two excursions be made every three weeks for the purpose of studying Natural History.' This was seconded by D. Pearce, and carried.

Secondly, 'That members of the College not in the Society be allowed to attend, permission having been obtained from the President.' This was seconded by J. Allen, and carried.

R. P. Ogle proposed 'That the excursions be only open to the Society,' but the motion was lost.

R. P. Ogle then proposed 'That the number of non-members be limited to two;' but the proposition finding no seconder, was lost. W. Claxton proposed eight as the number. This was seconded by H. Wills, and carried.

The rule, therefore, is as follows:—

'That two excursions be made every three weeks, for the purpose of studying, by practical observations, Natural History. That all members of the Society below the sixth form, or who have not otherwise taken an active part in the business of the Society, be obliged to attend two excursions in every term, under penalty of surrendering their places in the Society to qualified candidates. That members of the College, who are not in the Society, to the number of eight, be allowed to attend excursions with the President's permission.'

The President proposed E. J. Crosse as a Corresponding Member. E. T. Saunders seconded the nomination, and Mr Crosse was unanimously elected.

MEETING, MAY 31, 1872.

The PRESIDENT in the Chair.

The fourth meeting for the term was held on Friday, the 31st May, in the Physical Lecture-room. Twenty members were present.

The following donations were acknowledged:—Fossils from Clifton, Fish Teeth from Scotland, and Minerals by F. L. Penney, O.C.; Coins by Leaky; Fingers, with tentacles of *Platycrinus lævis*, or *triacontadactylus*, from Lower Shales, Clifton, by R. T. Montgomery; *Productus Martini*, *Modiola Macadami*, and other Fossils, from Clifton, by J. G. Grenfell, Esq.; *Modiola Sowerbyi*, and other Fossils, from Longdown, by W. Stoddart, Esq. of Bristol.

As there were so few members present, it was agreed to postpone the reading of Stevenson's paper on the Potteries till 14th June.

MEETING, JUNE 1, 1872.

The PRESIDENT in the Chair.

An extraordinary meeting was held on Saturday, 1st June, in the Mathematical Class-room.

This meeting was called to receive the resignation of the Secretary (J. F. M. H. Stone), who was about to leave the School. Twenty members were present.

The Secretary addressed the meeting, expressing his regret at leaving, and his good wishes for the future success of the Society. The President, in the name of the Society, expressed his sense of the loss it would suffer in the departure of the Secretary, who had occupied that post so ably for three years, and had worked most devotedly to promote the interests of the Society. He cordially thanked Stone for all that he had done.

Some conversation took place about electing a new Secretary. Nothing definite was done, so the meeting was adjourned.

MEETING, JUNE 7, 1872.

The PRESIDENT in the Chair.

The fifth meeting for the term was held on Friday, the 7th June, in the Physical Lecture-room. Twenty-three members were present.

This meeting was held for the purpose of electing two members of Committee, in place of Mr Stone, who had left the School, and Mr Oliphant, who had resigned.

H. Wills, proposed by Allen, and seconded by J. E. Jose; J. A. Gibbons, proposed by Ogle, and seconded by Tebbs; and Mr J. C. Jose, proposed by Stone, but declined, on the ground that he would be unable to attend the meetings. On a show of hands being made, Wills and Gibbons were unanimously elected.

The President proposed that the day of meeting should be changed for this term, from Friday to Thursday, at 6.45, being more convenient for the majority of the members. This motion was seconded by Gibbons, and carried.

Ogle proposed to make a rule that, before the close of every meeting, an opportunity should be given to members of asking questions connected with the management of the Society. The President, the Rev. J. Greene, and Allen, spoke against the proposal, which, as no one seconded, was lost.

Mr J. C. Jose gave notice that he should propose that ten members should form a quorum of the Society.

MEETING, JUNE 13, 1872.

The PRESIDENT in the Chair.

The sixth meeting for the term was held on Thursday, 13th June, in the Physical Lecture-room. Twenty-one members were present.

The President announced the following donations for the Museum:—

Shells, Corals, &c., from the Barbadoes (about thirty specimens in all), by J. A. Gibbons; Roman Coins, by Lukis; Fossils from Moser, and a piece of Carboniferous Shale, containing three Trilobites, found by himself.

The President then read a letter from Mr Barrington-Ward, offering a prize for Natural Science—a silver medal—and bronze medal for a second prize, if the competition be good. He proposed a vote of thanks to Mr Ward, which was seconded by Pearce, and carried unanimously.

Mr J. E. Jose then brought forward his motion that the quorum be fixed at ten members, which was seconded by Stevenson. Gibbons proposed an amendment, to insert the words "for this term," which was seconded by Pearce. A further amendment, to change the quorum to fifteen, was proposed by Don, and seconded by Tebbs; whereupon Gibbons withdrew his amendment. Don's motion was therefore carried:—"The quorum to be fixed at fifteen."

The President then called upon C. C. Stevenson to read his paper on the 'Potteries' (Part I.)

THE MANUFACTURE OF POTTERY.

The four great divisions into which the ceramic art of this country is to be divided are those of the Celtic or ancient British, the Romano-British, the Anglo-Saxon, and the medieval periods.

In the Celtic period the pottery consists mainly of cinerary or sepulchral urns, drinking cups, food vessels, and incense vases. They are formed of the coarse common clay of the place where manufactured, and are occasionally mixed with pebbles and gravel. These, you must bear in mind, are wrought entirely by hand, without any wheel, and the larger vessels especially are very thick. From their very imperfect firing, the vessels of this period are usually called sun-baked or sun-dried. This, however, is a grave error, for if the vessels were merely sun-dried, their burial in the earth would soon soften them, and they would long ago have returned to their old consistency. As it is, they bear evidence of the action of fire, and are indeed sometimes burned sufficiently for the clay to have attained a red colour.

The cinerary urns of Staffordshire—*i.e.*, such as have contained, inverted or otherwise, the burnt bones and ashes of the dead—vary considerably in form, like those of Derbyshire, from those of any other districts. They vary from nine to eighteen inches in height, and their ornamentations, which are always produced by indenting twisted thongs into the pliant clay, or by simple incision, is often very elaborate. This ornamentation usually consists of diagonal lines or of herring-bone or zigzag lines, arranged in different ways, and producing a remarkably good effect. Of these interesting vessels some excellent examples have been found in Staffordshire, which were no doubt made on the spot. They are therefore the very earliest sort of Staffordshire pottery, dating back to the time when that district was in possession of the *Cornavii*.

The Celtic drinking vessels found in the Staffordshire and Derbyshire barrows are generally from about six to nine inches in height, tall in form, contracted in the middle, globular in their lower half, and expanding at the mouth. They are usually very richly ornamented with indented lines in different patterns; are carefully formed by hand, of fine and well-tempered clay mixed with sand, and are well fired.

The food vessels are usually very wide at the mouth, tapering downwards gradually, and quite small at the bottom. They are formed of clay of much the same quality as the cinerary urns, and are baked to the same degree of hardness.

The incense cups of Staffordshire, like those of Derbyshire, vary in form and in style of decoration. They are very small vessels, not more than from an inch and a half to three inches in height.

The ornaments are, as in other remains of this period, incised or indented lines.

During the Romano-British period, although most of the finer vessels used in England were imported by that conquering people, a large variety of wares were made of native clays in different districts which they inhabited. At this time, although it is almost certain that wares of some kind were made in Staffordshire, there is no positive evidence of such being the case. In the adjoining county of Salop a considerable pottery existed, from which fact we may gather that Staffordshire clays were well known to the Romans. Again, the fact that Chesterton, by Newcastle-under-Lyne, was a Roman settlement, and a Roman road traversed the district of the present potteries, tends to prove the truth of the above statement. There is every reason for supposing that at least some of the finer kinds of red ware, commonly known as '*English Samian*,' were made in Staffordshire. At any rate, that clay would produce that ware, and many remains of it have from time to time been found in the district.

At Welton, and in many other parts of Staffordshire, Romano-British pottery has often been found, and there are reasons for believing that some was manufactured in the district.

The pottery of the Anglo-Saxon period consists almost entirely of cinerary urns, the form of which is somewhat peculiar. Instead of being wide at the mouth, like the Celtic urns, they are contracted, and have a kind of neck instead of an overhanging lip or rim. The pottery of this period is usually of a dark-coloured clay, sometimes nearly black, at others dark brown, and occasionally of a slate or greenish tint. The vessels appear to be hand-made, and are tolerably well baked. The ornaments usually consist of encircling incised lines, in bands or otherwise, and vertical or zig-zag lines arranged in a variety of ways, and not unfrequently knobs or protuberances are to be seen on the urns. Sometimes, also, they present evident attempts at copying the Roman egg-and-tongue ornament.

The marked feature of the pottery of this period is the frequency of small punctured ornaments, introduced along with the lines and bands with very good effect. These ornaments were evidently by the end of a stick cut and notched across in different directions, so as to produce crosses and other patterns. This novel and only mode of decorating this pottery will be best shown by this illustration. These notched stick-punches were used for pressing into the pliant clay.

Among the Anglo-Saxons the bowls were principally of metal or wood, generally ash, and the drinking vessels of horn and glass. The fact of these two essentials being made of wood or

metal, accounts for their using clay but little except for funereal urns. These drinking vessels of horn and glass were the origin of our 'tumblers,' the glasses then made being rounded at the bottom, so that they must be filled while held, and could not be set down until emptied without spilling.

Of Norman pottery no traces have been found in Staffordshire, though there is little doubt that at this period Norman potters did work the clays of that district. A discovery of a Norman pot-work has been recently made in Derbyshire. The clays are usually of a coarse kind, and the vessels generally appear to have been made on the wheel. In colour they are sometimes of a reddish brown, at others of a tolerably good red, and at others again nearly black; and one great peculiarity is, that many of the pitchers or jugs are covered with a green glaze. They are generally devoid of ornament, with the exception of having the ends of the handles rudely foliated by the pressure of the workmen's fingers. On one large vessel which has been exhumed are seen the horse-shoes, the badge of the Ferrars family, laid on in slip, and a kind of herring ornament scratched into the soft clay.

The medieval vessels made in Staffordshire, like those of other districts, were chiefly confined to jugs and pitchers of much the same form as the Norman pottery. Dr Shaw, in his 'History of the Potteries,' says—'There exist documents which imply that during many centuries considerable quantities of common culinary articles were made from a mixture of different clays found in most parts of the district. In the account of expenses of Sir John Howard in 1466 is the following entry, which shows somewhat curiously the cost of pots in that day:—"Watekin of Stoke delyvered of my money to on of the poteres of Horkesley ivs. vid., to pay himselfe and his felawes for xi dozen of potes, 4½ per dozen."'

The pottery of the Tudor period consisted of costrels and other vessels for ordinary use. They were coarse in material, but generally thickly coated with glaze, and the surfaces well mettled. Ornaments were not often introduced, but occasionally heads grotesquely formed decorated the handles; and other equally rude devices were laid on in different clays. Excellent examples of this may be seen in various collections, and are well worthy of increased notice. During this period, it must be borne in mind that the greater part of the wares in use were imported.

It has often been asked why the potters fixed themselves here, or the potteries of Staffordshire continued to flourish more than those of any other part of the kingdom. The answer to this

question is pretty obvious. The abundant and almost inexhaustible supply of clay and coal upon the spot, and the inland situation of the district, which contributed to render labour cheap, combined to fix and establish this important branch of commerce where it had been so successfully commenced. The measures or strata by which the beds of coal are divided consist most commonly of clays of different kinds, some of which make most excellent fire-bricks for building potters' kilns in which the ware is fired. Finer clays of various colours and textures are likewise plentiful in many places, most of them near the surface of the earth ; and of these the bodies of the wares used were formerly to be manufactured. The coals also in those days obtained were plentiful and cheap.

Dr Plott, in his "History of the Staffordshire Potteries," written 1686, says that coals were sold as low as twopence the horseload, which at eight horseloads a ton (the usual estimation) amounts to only 1s. 4d. a ton. In 1795, we find the price of coals in the same neighbourhood to be 4s. or 5s. a ton ; while now, by a gradual rise, a ton of coal cannot be purchased for less than ten shillings. When coal was first obtained, it was only necessary to remove the clay and soil which covered it. The "Potteries" is a name applied to several townships extending in a continual line for some seven miles in length, all in the parish of Stoke-on-Trent, of which Barsland is the ancient seat of the pottery. It is somewhere denominated a *butter pottery*, which appellation I will presently explain.

There are different sorts of clay—1, Bottle clay, of a bright whitish-streaked yellow colour ; 2, hard fire-clay, of a duller whitish colour, and interspersed with a dark yellow, which they use for the black wares ; 3, being mixed with the red blending clay which covered it ; 4, white clay, so called, it seems, because, though of a bluish colour, it is used for making yellow-coloured ware. Yellow is the lightest colour of which they make any ware. All which they call *throwing* clays, because they are of a closer texture, and will work on the wheel. None of the other clays, which they call *slips*, do this, as they are of a looser and more friable nature. These mixed with water they make into a consistence thinner than a syrup, so that, being put into a bucket, it will run out through a quill, and is the substance with which they paint their wares. Of these slips, 1st, is the orange slip, which before it is worked is of a greyish colour mixed with orange balls, and is used to give the ware (when annealed) an orange colour ; 2d, the white slip, which before it is worked, though of a dark bluish colour, makes the ware yellow, and, as being the lightest colour they use in making any ware, they

call it (as they did the clay above) the white slip; 3d, the red slip, made of a dirty reddish clay, which gives the ware a black colour. None of these clay slips must have any gravel or sand in them.

Upon this account, before it be brought to the wheel they prepare the clay by steeping it in water in a square pit, till it be of a due consistence; then they bring it to their *beating-board*, where with a long spatula they beat it till it be well mixed; then being first made into large squarish rolls, it is brought to the *waging-board*, where it is slit into flat thin pieces with a *wire*, and the least stones or gravel taken out of it.

This being done, they *wage* it, *i.e.*, knead or mould it like bread, and make it into round balls proportionately to their work, when it is brought to the wheel and formed according to the judgment of the workman. After the potter has wrought the clay into hollow or flat ware, he sets it abroad to dry in fair weather, but by the fire in wet, turning it as seems fit. This operation is called *wharing*. When they are dry they *stouk* them, *i.e.*, put ears and handles to such vessels as require them. These also being dry, they *slip* or *paint* with their several sorts of slip according to the design; when the first slip is dry, laying on the next at leisure, the orange slip making the ground, and the white and red the paint.

These two colours they break with a wire-brush much after the manner that paper is marbled, and then cloud them with a pencil when tolerably dry. After the vessels are painted they *lead* them with that sort of lead ore they call *smithum*, which is the smallest ore of all, beaten into dust, finely sifted, and strewed upon them; by this process they impart a gloss but not the colour.

The colours are chiefly given by a variety of slips, except the motley colour, which is produced by blending the lead with *manganese*, by the workmen called *magnus*. But when they intend to show the utmost of their skill in giving their wares a finer gloss than ordinary, they lead them with lead calcined to a powder, which they also sift fine, and strew upon them as before. This not only imparts a greater gloss, but goes much further in their work than lead ore. Afterwards they are carried to an oven above eight feet high and six feet wide, of a round copped form, where they are placed one upon another from top to bottom; if they are ordinary wares, they are exposed to the naked fire without being leaded. All the flat ware is exposed to the naked fire, having only parting-shards, *i.e.*, thin bits of old pots placed between them to keep them from sticking together. But if they be leaded hollow wares, they are not exposed to the naked fire,

but are put in potters' kilns, called *saggars,* which are coarse metalled cases made of marl.

In these they generally put three pieces of clay, called *bobbs,* for the ware to stand on to keep it from sticking to the *saggars.* This word is a corruption of the German *schragars,* which means supporters or cases. By reason of the leading they would naturally stick together if not put in *saggars,* which also serves to screen them from the vehemence of the fire, otherwise apt to warp, if not melt them. In four-and-twenty hours an oven of pots will be fired, then they let the fire die out gradually, and in ten hours more the oven pots will be entirely finished, when they are drawn for sale. Their chief purchasers were in those days poor cratemen, who carried them on their backs all over the country.

The common glaze was produced by lead ore finely powdered, and sprinkled on the pieces of ware before firing ; sometimes with an addition of a little manganese for the sake of the brown colour it imparts. When an extra gloss is required, calcined lead is employed instead of lead ore, but still sprinkled on the pieces in the same rude manner. Glazing by salt appears to have been discovered about 1680, which gradually took the place of the lead ore formerly used.

The following is the curious account given of this discovery :— ' At Mr Joseph Yates', Stanley, near Bagnall, five miles east of Burslem, a servant was preparing in an earthen vessel a *saltlery* for curing pork, and during her temporary absence the liquid boiled over and the sides of the pots were quickly red-hot from intense heat ; yet, when cold, were covered with an excellent glaze. The fact was detailed to a potter in the neighbourhood, who availed himself of the lucky occurrence, and told other potters. The ovens employed for the purpose being used only once weekly, and the ware being cheap, were large in diameter, and very high, so as to contain a sufficient quantity to be baked each time to cover all expenses contingent. They were constructed with a scaffold all round them, on which the firemen could stand while casting in the salt through holes made in the upper part of the cylinder above the bags or inner vertical flues. The saggars were made of completely refractory materials, with holes in their sides for the vaporised salt to circulate freely among all the vessels in the oven, so as to affect their surfaces. The wares thus glazed and made from the common clay with a mixture of fine sand was called " Crouch ware," and of this all the ordinary articles of domestic use, including jugs, cups, dishes, &c., were made. The manufacture of *butter-pots* seems to be the first

sort of pottery made. An Act of Parliament was passed compelling Burslem potters to make their butter-pots of a size to hold 14 lbs., and sufficiently hard not to imbibe moisture; hence the above appellation of *Butter Pottery.*'

Afterwards the Society proceeded to elect Directors for the Entomological and Botanical Sections. For the Entomological Section, W. Claxton, proposed by Don, seconded by Gibbons, was elected. For the Botanical Section, D. Pearce, proposed by Allen, seconded by Tebbs, was elected.

MEETING, JUNE 27, 1872.

The PRESIDENT in the Chair.

The seventh meeting for the term was held on Thursday, June 27, in the Physical Lecture-room. Nineteen members were present.

Donations acknowledged:—A Slab found in the Bone Bed, containing eight fish-teeth, presented by the President; Small Crystals of Selenite from the Oxford Clay, by C. Blanshard, (o.c.); Fragment of an Ammonite showing the Sutures; Fossil Wood and specimens of *Rhynchonella variabilis* from Horfield, by the President; a Piece of Rock cut by the Diamond Drilling-Machine from the Tunnel on the Durdham Downs, by J. Routh.

C. C. Stevenson then continued his paper on 'Potteries' (Part II.)

I will now proceed to a more modern mode. The present art of manufacturing pottery and porcelain divides itself into four different and distinct branches, the first of which comprehends a knowledge of the nature and peculiar properties of the various materials whereof the vessels are composed; the second comprises the methods used in combining these materials, and in fashioning the vessels; the third branch includes the choice and management of the colours and enamels employed in painting and ornamenting the wares, together with the operations necessary for their conversion; and the last division embraces the means required for completing the manufacture by the assistance of fire. The chief ingredients employed in making all kinds of pottery are clay and flint; these are both classed by chemists among the primitive earths. The first of them in its state of purity is denominated *alumina* or *oxide of aluminium*, and the latter is called *silica* or

oxide of silicon. Clay is an opaque and non-crystallised body, of dull fracture, soft enough in all states to take a mark from iron; when breathed on, it exhales an odour, which, from its peculiarity, takes its name from the material, and is termed argillaceous. This is owing to the oxide of iron with which it is mixed, as clay, when absolutely pure, does not exhale any odour.

Clay forms with water a plastic paste, having considerable tenacity, which by the action of heat is brought to a very great degree of hardness; it is compact and smooth, almost unctuous to the touch, and when dry may be easily polished by the finger. It is not soluble in water, but mixes readily with it in all proportions, parting with difficulty from the last portion of that which it has absorbed; it will adhere to the tongue. The description of clay employed by potters is infusible in the heat of a porcelain furnace, when some kinds, owing to their being combined with oxide of iron, assume a red colour, while others have a pure white. The highest temperature to which clay can be exposed tends only to increase its density, hardening its substances, and diminishing its volume.

The second ingredient, silica, or pure flint, is commonly found in most parts of the world in primitive mountains, frequently embedded in chalk, in great abundance. In Scotland and Ireland it occurs in secondary limestone. Flint abounds in alluvial tracts in the form of gravel; an inexhaustible supply of excellent quality might be collected on some parts of the sea-coast of England, and particularly in the neighbourhood of Brighton, where there is enough of this material known under the name of shingle to serve the whole manufacturing wants of England for ages yet to come, while its removal would be attended with advantage to the place where it is now situated. Flint is silica in a state nearly approaching to purity, its constituents being—

Silica,	98·00
Lime,	·50
Oxide of iron,	·25
Alumina,	·25
Loss,	1·00
	100.00

It is usually of a grey colour, with occasional striped delineations occurring in its substance. It is obtained chiefly in rolled pieces, but often occurs in irregular blocks. Internally it has a glimmering lustre, its fracture being conchoidal, and its fragments sharp-edged. Silica may be found existing in solution in the Bath waters, and in some mineral springs in Bohemia, while the celebrated fountain at Rykum, in Iceland, deposits so considerable

a quantity of silicious earth that a solid cup has been formed around it, rising to a considerable height. This solution of silica is probably owing to the solvent power of soda, which is present in the two latter waters. The best flints are of a dark grey colour, approaching to black, and having a considerable degree of transparency. Those which exhibit brown or yellow spots on their interior surfaces should be rejected on account of the ferruginous particles which they contain, and whence would arise blemishes in the ware.

The clays principally used in the potteries of Staffordshire are brought from Dorsetshire and Devonshire. These earths are both of excellent working quality, and being free from any impregnation of iron, are valuable for the extreme whiteness which they exhibit when burnt. The Dorsetshire clay is brought from Purbeck, being of two kinds, distinguished as brown clay and blue clay. That from Devonshire comes from the southern part of the county, and is of two distinct qualities, known as black and cracking clay.

The clay from Dorsetshire is considered preferable to that from Devonshire for the potter's use, so that it commands a price in the Potteries equal to one-eighth more than the latter. The good qualities of brown clay are, that it burns an excellent white, and is not liable to crack during the process of burning. On the other hand, it is subject to considerable imperfection of crazing, which causes some manufacturers to discard the use of it altogether from their works. Crazing is a technical term used to denote the cracking of the glaze, which is supposed to arise from the imperfect manner in which this is capable of uniting itself with the clay composing the body of the vessel.

The blue clay combines the greatest number of good qualities, and is the most generally esteemed of all the four I have mentioned. It burns exceedingly white, making a very solid quality of ware, and is capable of being advantageously combined with a greater quantity of silicious earth or flint than any other kind. The greater the quantity of silica used, the whiter the ware will prove: the limit to the use of flint being the inability of the clay to bear it in combination beyond a certain proportion without cracking.

Black clay owes its distinctive colour to the quantity of bituminous matter which it holds in combination, but which is entirely consumed and dissipated when the clay is submitted to the heat of the oven, leaving the articles produced from it of a colour the whiter in proportion to the original blackness of the clay. Cracking clay is so called from an evil property of occasioning the ware to crack while undergoing the first application of fire. To compensate in some degree for this irregularity, the goods in the

manufacture of which it is employed prove of an extreme whiteness. Much judgment and experience are necessary in the using of this clay, that its tendency to cracking may be as far as possible obviated by a proportionate admixture. If clay of any description were dried without the addition of any other body after being made sufficiently plastic to be modelled on the potter's wheel, it must inevitably crack, as the evaporation of its water will occasion it to shrink in the proportion of one part in twelve during the process of drying.

Another description of clay much prized for the manufacture of finer kinds of earthenware and porcelain was found in Cornwall by a Mr Cookworthy, and is commonly denominated China Clay. This is very white and unctuous to the touch, and is obviously formed by the gradual disintegration of the felspar of granite. There are large mountains of this mineral, some of which are thus partially decomposed; this China clay proves on examination to be identical with the *kaolin* of the Chinese. It is prepared by the clay merchants on the spot where found. The stone is broken up into pieces of a small size and then thrown into a running stream; there the light argillaceous parts are washed off and held suspended in the water while some ponderous mica and quartz remain at the bottom of the stream. At the end of the rivulet the water is stopped by a dam, and the pure clay gradually subsides. When this deposit is completed, the clear water is drawn off, and the solid matter dug out in square blocks, which are placed on shelves and exposed to a continued current of air until sufficiently dry to be packed in cases for shipment. The clay, which is then in the state of a fine powder, is very smooth and of an extreme whiteness. Mr Wedgewood found by analysis that it contains sixty parts of alumina and twenty parts of silica. In preparing the clay, the first operation of the potter is that of mixing it with water to the consistence of cream.

It is well known that water collected from springs and from many streams contains various foreign matters, some of which would be injurious to the composition of porcelain. It is therefore necessary to examine chemically the properties of water, and to counteract any bad qualities that may be found existing, as far as possible. The French manufacturers are accustomed to employ only rain-water, while in Germany, still more precise in their operations, the manufacturers prepare their materials only twice in the year, at the vernal and autumnal equinoxes, acting under the impression that there is some peculiarity in the rain which better qualifies it for the purposes of their manufacture.

The mixing of the clay, which is called *blunging*, is effected in a trough five feet long, three feet wide, and two and a half

deep. In order to break down the clay fully, and amalgamate it with the water, a long wooden instrument is used, formed with a blade at one end and a cross handle at the other, which is moved violently about in the trough in all directions. In large manufactories, where machinery takes the place of ordinary workmen, the *blunging* is effected in the following manner :—The clay is thrown into a cast-iron cylinder four feet deep and twenty inches in diameter. Through the centre of the cylinder runs an upright shaft furnished with knives placed at right angles to the shaft, but so arranged on it that their flat sides are in the plane of a spiral thread, so that by the revolutions of the shaft the knives perform the double office of cutting whatever stands in their way and of forcing downwards the contents of the cylinder in the manner of a screw. A second set of knives is inserted in the interior surface of the cylinder, and these extend to the shaft in the centre parallel to and corresponding with the revolving knives: thus the two sets, the one active, the other passive, have the effect of shears in cutting the clay into small pieces ; while this in its reduced state is at the same time forced through an aperture at the bottom of the cylinder and transferred to a vat for the purpose of being mixed with water : a process which this previous dividing of the clay is found materially to facilitate. The vat where this mixture is performed is likewise of a cylindric form, its diameter being equal to four times its depth. In the centre of this vat also a perpendicular shaft is inserted, furnished with cross arms or radii, one below the other. These cross arms are connected by upright staves, giving the appearance of two opposite gates hung upon the central shaft. These revolve within the cylinder ; and as they are partially immersed in the pulp, the constant agitation mixes all the finer particles of clay with the water, while stony particles of greater magnitude fall to and remain at the bottom. The pulp, now mixed to the consistence of cream, is passed off from the vat through a series of sieves of increasing degrees of fineness, which are worked to and fro by machinery; thus a separation is effected between the grosser parts and that portion which is fitted to enter the composition of the ware.

The operation of *throwing* consists in shaping such vessels as are circular, and is performed upon a machine called a potter's lathe. This is an upright shaft about the height of a common table, on the top of which is fixed a circular piece of wood, the breadth being sufficient to support the widest vessel that may be required. The bottom of the shaft runs in a step, and the upper part in a socket a little below the circular board, so that the shaft and board turn together. The shaft has a pulley fixed on it, by means of which it is turned, a band passing round the pulley from a wheel placed

at a short distance, and which is ten times the diameter of the pulley. The wheel, when turned by a handle, sets the lathe in motion. The clay to be thrown is first cut and weighed, being formed into a ball. It is then placed on the face of the circular board, which being put in motion, the thrower, dipping his hands from time to time into water or slip that the clay may not adhere to them, fashions it first into a long thin column, which he forces again down into a lump, repeating these operations until assured that no air bubbles can possibly remain in the body of the clay. He then directs the speed of the wheel to be moderated, and proceeds to give the first form to the vessel. This is done with his fingers alone, or with the aid of an instrument shaped according to the desired form. The instruments employed for this purpose are called *profiles* or *ribs*. By the assistance of one of these the inside is smoothed and made to assume the requisite shape, when any inequalities, technically termed *slurry*, are removed. Finished to the artist's satisfaction, the work is removed and cut from the lathe by passing a thin brass wire through the lowest part of the clay. The vessel is then lifted off and placed on a board or shelf, where it is left to dry partially before it is further smoothed and shaped in the turning-lathe.

To some earthenware they impart a milled edge in what is called an engine-lathe, where, in addition to the rotary motion communicated to the article, it has likewise a horizontal movement to and fro, enabling the workman to make the requisite incisions at proper and definite intervals. Taken from the turning-lathe, handles, spouts, &c., are affixed. In the present state they are ready to undergo the first application of fire in the oven. For this purpose they are placed in deep boxes called *saggars*, made of a mixture of fire-clay and old ground *saggars*, which should be well baked, and capable of sustaining the most intense degree of heat without being fused. The porcelain manufacturers labour under a considerable disadvantage in this respect, being unable to procure materials for the construction of these cases that will sufficiently withstand the direct heat of the furnace. To prevent any adhesion of the pieces to the *saggars*, the flat bottom of each is covered with a thin layer of fine white sand. That this even may not adhere to the porcelain, the Chinese strew over the sand some dry *kaolin* in powder. Pieces of any considerable size must each be enclosed in a separate case, but smaller objects, such as cups and saucers, may be placed together; but no piece may be placed in or on one another in a *saggar*, and all must be so arranged that the heat will be equally applied to every part of each. If the clay whereof they are composed be well chosen and carefully managed, the *saggars* may be placed from fifteen to twenty several

times in the furnace before they are rendered useless. The largest and coarsest *saggars* are usually placed on the floor of the oven, which must be previously covered with a layer of sand.

If the heat be not equally distributed through the whole area, some pieces would be injured by excessive firing, while others would be inadequately baked. The bottom of the *saggars* being flat, each, as it is placed upon another, forms a cover to the one beneath, and the entrance of smoke is further prevented by placing a ring of soft clay on the upper rim of each case. In this way the *saggars* are built up to the top of the oven, the uppermost being always left empty. Each of these piles, as it stands, is called a *bung*. The process of baking usually lasts from forty-eight to fifty hours, during which time the heat is gradually increased. In order to ascertain when the baking has been carried far enough, the ovenman places trial pieces in different parts of the oven, but so disposed that they can be readily taken out for examination. These pieces are rings made of common Staffordshire fire-clay, which is found to have the property of changing its colour with each accession of heat. By comparing these rings therefore with pieces of the same clay which have previously been sufficiently baked, and which serve as a standard, the actual progress of the wares in the oven may at any time be ascertained precisely. When the appearance of these trial pieces is judged satisfactory the firing is then discontinued, the furnace and ash-pit doors are closed, and the oven, with its contents, left to cool gradually twenty-four or thirty hours. From the similarity of the ware in this state to the appearance of well-baked ship-bread, the ware is now called *biscuit-ware*.

If it were attempted to apply the glaze to articles of porcelain and earthenware without their previous conversion into biscuit-ware, their texture and shape would be injured by the absorption of water from the glaze. It must be borne in mind that the shrinking of clay upon the application of heat is permanent, and that no alteration of its bulk will occur, unless it be subjected to a still higher degree of temperature. By limiting, therefore, the heat of the gloss-oven, in which the baking is finished, below that applied to the biscuit, the risk of cracking the glaze through the contraction of the ware is obviated. The glaze usually employed for common kinds of earthenware is compounded of litharge of lead and ground flints in the proportion of ten parts by weight of the former to four parts of the latter. Cornish granite is sometimes substituted for flint, and used in the proportion of eight parts to ten of litharge. This method of glazing is objectionable on account of the injury which, notwithstanding every precaution that can be taken, it occasions in application to

the health of the workmen employed, who are frequently seized with paralysis, and because the lead, which is soluble by means of acid, and deadly poisonous, renders vessels thus glazed improper for preparing or containing many articles of human food. The bad effect of raw glazes upon their health is greatly lessened to the workmen when they can be brought to the frequent use of ablutions. In every pottery the men employed in glazing are plentifully supplied with soap, which they are enjoined to use before quitting their work. Glazes for porcelain and the finer kinds of earthenware are generally made with white-lead, ground flints, glass, and common salt, Lyme sand, combined with soda as a flux, being frequently added to the ingredients just mentioned; but as almost every manufacturer uses a different glaze, and the recipe is kept secret to himself, under the impression of its superiority compared with that used by his competitors, it is not possible to state proportions with accuracy.

The French porcelain makers have given the composition of hard glazes made by them, which are all said to be formed of flint, ground porcelain, and crystals of calcined gypsum in the following different proportions:—

	No. 1.	No. 2.	No. 3.
Calcined flint, . . .	8 parts.	17 parts.	11 parts.
Ground porcelain, .	15 „	16 „	18 „
Crystals of calcined gypsum,	9 „	7 „	12 „

It is necessary to vary the composition of the glazes in order to suit the different materials that form the body of the ware. The quantity of lead which enters into the composition of the better kinds of glazes is so small, that the deteriorating and pernicious effects which attend the use of raw glaze need not be apprehended from their application. The *saggars* used to enclose the wares, when baked in the gloss-oven, are similar to those employed in the first firing. Previous to their insertion the pieces must have the glaze wiped from the parts which immediately rest upon the bottoms of the *saggars*, otherwise they would adhere, and might be broken on their removal. The cases are piled up in the manner already described, and just that degree of heat is employed which will give perfect fusion to the glaze, and cause it to spread regularly over the surface, the temperature, of course, varying according to the quality of the articles and the composition of the glaze. The temperature of the gloss-oven is generally about 1300 degrees less of Fahrenheit than the heat of the biscuit-oven. The glaze, as seen in the finished porcelain, should not impart a lustrous appearance, but, while beautifully smooth to the touch, should present to the eye rather the softness of velvet than the gloss of satin. This peculiar semblance

will only be produced with glaze that melts with difficulty, and when the heat has been raised precisely to and not beyond the point that is requisite for its fusion.

The art of painting on earthenware, though of comparatively recent introduction into England, is by no means a modern invention. It is well known that the ancients manufactured coloured enamels, and some specimens of the art made by the Egyptians more than three thousand years ago have been preserved to the present day, which is an evidence of this fact. In this branch of the art there are various objects to be considered, a proper acquaintance with which is necessary to success. Such are the composition of colours; the fluxes which are necessary to render these fusible, which unite them to the wares, and in many cases impart brilliancy to their tints; the vehicle employed in laying on the colours, and the course to be pursued in fixing them on the porcelain by means of heat.

Metallic oxides form the bases of all vitrifiable colours, but every metallic oxide is not proper for being employed in decorating porcelain. Some are very volatile, as the oxides of mercury and of arsenic. Others part so freely with the oxygen they hold in combination that their colour proves uncertain, and varies with every application of heat; such are the pure-coloured and red oxides of lead, and the yellow oxide of gold. Oxides which are susceptible of great variations are very seldom employed. Black oxide of iron is not used alone for producing that colour on porcelain; and the green oxide of copper, as formerly prepared, was so uncertain that it was very rarely employed, but the defect has of late been greatly remedied. Oxides uncombined with other substances are not susceptible of fusion; and although they may be attached in thin strata to vitrifiable bodies by a very violent heat, yet their colours, with the exception of lead and bismuth, would in such cases become dull, and possibly be even destroyed. In order to promote their fusion a flux is therefore added, the composition of which varies according to the means employed for diluting the colours at the time they are used. Where a volatile oil is chosen for this dilution, a flux composed of glass, nitre, and borax is most proper; but when gum-water is substituted for this volatile oil, the flux must be varied, because borax cannot be properly diluted in gum-water. A compound of glass, lead, and silex is therefore prepared by some. Another compound extensively used consists of—powdered glass, 40 parts; calcined borax, 22 parts; refined nitre, 44 parts. It is essential that not only the borax and nitre be as pure as they can be rendered, but also that the glass shall not contain the smallest particle of lead in its composition. These in-

gredients must be first well mixed in a glass mortar with a pestle of the same material for an hour, and then exposed in a crucible to the heat of a charcoal fire until the swelling, which for a time accompanies the fusion of the mass, has ceased. By means of this flux the colours are fixed on the porcelain, and made to assume a resplendent appearance. The metallic oxides, being enveloped by the flux, are preserved from all contact with the air, and this colour is rendered permanent, the fusion having been promoted at a temperature too low for the destruction.

Enamel is glass rendered opaque by the oxide of tin and by the oxide of lead. All glazes that contain lead participate in the properties of enamel. Raw glazes used for covering tender porcelain are of this nature. The colours employed in painting this porcelain are those which serve for painting in enamel; they require less flux than others, because the surface to which they are applied becomes soft enough to be penetrated. Hard porcelain, whose nature is identical with those of China and Saxony, has two kinds of colours applied to it. The liquid matter which serves as a vehicle in laying on the colours is rubbed with them upon a glass palette until the whole is intimately united. The mixture must be brought to that state of dilution which is most proper and convenient for its application with a hair-pencil on the surface of the porcelain. Purple and violet colours are procured by dissolving gold in *aqua regia* (nitro-muriatic acid), and immersing a bar of pure tin in the solution. The product thus obtained is called, from its inventor, the 'precipitate of Cassius,' and is used generally for giving the above-mentioned colour to porcelain. A preferable way of preparing this precipitate is to dissolve the two metals separately, and by then mixing the solutions together in different proportions, various shades of carmine, violet, and purple are obtained. The first of these three tints is seldom used in porcelain works; for although extremely beautiful, it is also very transient, and may be easily spoilt by a small excess of heat, or by contact with carbonaceous vapours—a circumstance which is the less important, as its place may be well supplied by a rose colour obtained from iron, which is not liable to the same disadvantage. Carmine colour, when used for tender porcelain, is prepared with fulminating gold (made by dissolving the metal with *aqua regia*, and precipitating with ammonia) and muriate of silver. This compound being without any admixture of tin, shows that a union of the oxide of tin with that of gold is not necessary for the production of purple. A violet colour is also made with the purple oxide of gold.

To obtain a yellow colour for both hard and tender porcelain,

white oxide of antimony mixed with sand and oxide of lead are employed, the latter substance serving as a flux to the others. Very great carefulness is required in the preparation, as the lead frequently approaches by reason of the heat to a metallic state, when it appears in the form of black on the ware. Oxide of tin is sometimes added; and when a livelier colour is wanted approaching to that of saffron, red oxide of iron is added, the too great redness of this being subdued by the action of the lead in the fusion which the ingredients undergo previous to their application to the porcelain. The colours thus produced are not susceptible of change, but if exposed to the full heat of a porcelain furnace would be entirely dissipated.

For the production of blue, well-prepared and very pure oxide of cobalt is employed, mixed with a flux. Oxides of tin and of zinc, added in different proportions, give different shades, from a deep rich colour to a light blue. The rich smalt known under the name of azure-blue is only the glass of cobalt mixed with sand. This colour must be fused in a crucible, and reduced to an impalpable powder in an agate mortar; after which it may be used in combination with flux. Green oxide of copper is usually employed for the production of a green colour. On precipitating in different vessels by means of potass solutions of copper which are equally pure and concentrated, it is perceptible that the precipitate is formed more quickly in some vessels than others; and if these different products are separately collected, those which are most promptly formed are when dry of a fine bright green, and produce a corresponding colour on porcelain.

Gilding on porcelain or on glass is performed either with or without the addition of a fluxing material, the gold being made to adhere to the surface by the incipient fusion either of the glazing on the porcelain or on the surface of the glass or flux employed. Gold is used for this purpose sometimes in the form of leaf-gold, and at other times in that of a powder prepared either mechanically or by some chemical precipitation. When the first of these two methods is employed, leaf-gold must be ground with honey or gum-water of an equal consistence, the honey or gum being afterwards washed away. The gold may be kept for use in paper or in shells, and the use of these latter recipients has occasioned this powder to be known among artists as shell-gold. This precious metal, about £4 an oz., is precipitated from its solution in *aqua regia* by adding to it a dilute solution of green vitriol (proto-sulphate of iron) or strips of metallic copper. Gold powder may also be obtained from the same solution by distilling it to dryness; but this process is not so convenient as precipitation. When gold powder is used, it

must be mixed with gum-water as a vehicle. Where it is intended to apply leaf-gold without any fluxing material to the body of the ware, these should be moistened at the requisite parts with a weak solution of gum-arabic, which must afterwards be allowed to dry. When the gold is applied, the porcelain or glass may be made sufficiently adhesive to it. If a flux is employed, it should, after being rubbed very fine with a muller, be diluted with gum-water and very thinly spread over the parts which it is designed to ornament. When very nearly dry, the leaf-gold is laid upon it.

Burnishing, which is the last process performed in the manufacture of ornamented porcelain, is generally intrusted to female hands. The implements required for this purpose are a burnisher of agate or blood-stone, some whitelead, a piece of sheepskin for wiping the ware, and some vinegar. As extreme cleanliness is indispensable, the person engaged in burnishing does not even touch the porcelain or her implements, but interposes between them and her hands a piece of clean white linen. The agate burnisher should be applied very lightly on the gilding, following all the ornaments, and never rubbing in cross directions lest the gilding should appear scratched. After having rubbed the gilding for some little time, a little vinegar or whitelead should be applied to cleanse the surface. This being removed with a soft linen rag, the burnishing is recommenced and continued until the gilding throughout assumes a satisfactory appearance.

All considerable manufactories have enamelling kilns of various sizes. These are in form like a chemist's muffle, from about six to ten feet long, and from three to five feet wide. The articles are placed in the kiln until it is filled, when, the mouth being closed, fire is applied for about eight or ten hours, at the end of which time the colours are found to be burnt into the glaze. The muffle is provided with trial pieces, which can be extracted from time to time during the baking, and will indicate the general state of heat of the contents of the kiln. When taken out, they are perfectly finished and ready for sale.

J. E. Jose, Esq., made some remarks on pottery found in tumuli in the neighbourhood, in the north of England, and in Norway, belonging to the bronze age.

The President thanked Stevenson for his interesting paper, spoke on the similarity of Mexican and Egyptian pottery, and described the progress of Grecian art as shown in their pottery.

J. E. Jose, Esq., asked some questions about the Society's excursion. The President said he would consult the Head-Master.

MEETING, JULY 11, 1872.

The PRESIDENT in the Chair.

The eighth meeting for the term was held on Thursday, July 11, in the Physical Lecture-room. Twenty members present.

Donations acknowledged :—Lava from Vesuvius enclosing a Coin (eruption in 1871), from A. Cole-Hamilton; Ores of Nickel and Cobalt from Switzerland; Cinnabar from California; Roman Coins found in Jersey Harbour, from Lukis.

J. Allen next read a most interesting paper on 'Opium,' exhibiting specimens of the poppy.

The President spoke on the paper.

D. Pearce had promised some 'Notes on the Clifton Birds,' but was unavoidably absent.

The President made some remarks on the 'Geology of Clevedon.'

MEETING, JULY 18, 1872.

The PRESIDENT in the Chair.

The ninth and last meeting for the term was held on Thursday, July 18. Forty members were present.

Donations acknowledged :—Corals, by C. H. Firth; Pecten, from the Carboniferous Limestone, and three kinds of Productus, by the President.

J. F. M. H. Stone was declared an Honorary Member.

C. Woodforde was proposed as Corresponding Member, seconded by J. Allen, and elected unanimously.

The Treasurer, J. Allen, then read the accounts for the term.

The President promised the Transactions should appear next term.

The Society then proceeded to the election of officers for next term.

For the office of Treasurer, J. Allen, proposed by Stone, and seconded by Ogle, was elected.

For the Committee, the Rev. J. Greene was first elected unanimously; for the remaining places, the following were proposed and elected :—Jose, Gibbons, Routh, and Wills.

THIRD TERM, 1872.

MEETING, September 27, 1872.

The President in the Chair.

The first meeting for the term was held in the Physical Lecture-room on Friday, September 27. Forty-five members were present.

The President acknowledged the following donations:—Head of a Teleosaurus from Upper Lias, near Whitby, by R. Montgomery; Otter Skin, by A. Cole-Hamilton; Iron Ore from the Pyrenees, by Taylor; Little Stint, by M. S. C. Richards, Esq., of Appledore, North Devon; Coal Measure Plants from Llantwit Vadre, Glamorganshire, by Lukis; Silicified Wood from Barbadoes and Silicified Corals, by J. A. Gibbons; Iron Ore and Fossils from new iron mine, Clifton, by J. G. Grenfell, Esq.

The President announced that the Committee had elected Dr Tilden an Honorary Member.

The President then read a paper on an 'Iron Mine recently opened in the Royal York Crescent, Clifton;' and exhibited a large number of specimens of the ore and some fossils of great interest.

An iron mine has recently been opened in the Royal Crescent, in the centre of Clifton, which promises to be of some importance. Mr Lewis came across the deposit in cutting a drain. It is singular that it should not have been discovered before, because large sums of money have been spent in searching for ore along these hills; and this deposit is so near the surface that the cistern of a house may now be seen actually sunk into it. The mine is sunk in the millstone grit which lies between the Coal Measures and the Carboniferous Limestone, and is composed of coarse sandstone and conglomerate, with occasional beds of shale.

These beds dip, 10° W., at an angle of 48°; their upturned edges form a very uneven surface, which is overlaid by horizontal beds, probably of Triassic age, varying from 5 to 12 feet in thickness, composed of a debris of clay with fragments of hæmatite, and containing a bed of nearly solid hæmatite in the lower part. Above these, again, there is a thin coating of recent surface soil. About 80 yards, a little to the south-west of this mine, another

large pit has been opened in which these Triassic beds become much more important, as their bottom has not been reached at a depth of over 50 feet, while at 30 to 40 feet a great horizontal bed of hæmatite is being worked 10 or 12 feet thick. This bed, however, rapidly thins out to the west, and must do the same to the east, so that it forms a lenticular mass.

These Triassic beds are evidently the debris of the millstone grit beds containing hæmatite which have been denuded.

Mr Lewis's mine is a pit about 60 feet long by 40 feet wide; the length being measured along the strike of the beds, and the breadth at right angles to this in the direction of the dips, south 10° W.

The beds at present exposed on the floor of the mine are eight in number.

No. 8. The highest of these beds in stratigraphical order is found at the lower part of the quarry, and consists of red sandstone with large cavities filled with hæmatite.

No. 7. Bed of hæmatite, 4 feet, in sandstone matrix.

No. 6. Laminated sandstone, red, with large *nereites* and shells.

No. 5. Bed of hæmatite, 4 feet, in sandstone matrix.

No. 4. Red clayey shale.

No. 3. Sandstone.

No. 2. Thick bed of sandstone with some hæmatite.

No. 1. Sandstone.

There are thus two beds of nearly solid hæmatite which, I have no doubt, will yield 50 per cent. metallic iron. The clay bed, No. 4, is also rich in iron, and is said to be of use for mixing with the harder and purer ore. The sandstone is of no use and is thrown away.

At the west end of the quarry the rocks come up to the recent surface soil.

The value of the deposit depends on three things:—

1st. The depth below the surface to which the beds of hæmatite already found extend. This is a very uncertain problem; in the Carboniferous Limestone of the north of England in the Pennine range are large deposits of lead and other minerals, but they are never—or hardly ever—found below a certain depth.

2d. When the Triassic beds to the north are removed, it is quite possible that new beds of hæmatite may be found parallel to those already described.

3d. It is a question how far these beds extend to the east and west along the line of strike. As the ore is interstratified with the sandstone beds, and does not merely fill up a pocket or a fissure in the rocks, there seems to be no reason why it should not extend to a considerable distance each way.

When these questions come to be worked out, it is of course possible that an unfavourable result may follow in each case, and we thus have a good illustration of the great risk of mining operations, which causes mines to be such dangerous and yet such tempting investments to persons of a speculative turn of mind.

We will now pass on to the character of the ore found. This consists of the sesquioxide of iron, of which there are three kinds:

1. Anhydrous sesquioxide or red hæmatite, Fe_2O_3.
2. Gœthite, $Fe_2O_3H_2O$.
3. Limonite or brown hæmatite, $Fe_2O_3 3H_2O$.

These are distinguished as follows:—

1. Red hæmatite; streak cherry-red or reddish-brown; crystalline; gives off no water when heated in glass tube; infusible; colour dark steel-grey or iron-black; of earthy varieties, red, including red ochre.
2. Gœthite; streak brownish-yellow; gives off a little water when heated; generally crystallised in prisms, or flat tables, or fibrous; colour reddish and blackish brown, yellowish by reflected light, often blood-red by transmitted light. Before blowpipe blackens and becomes magnetic, forming Fe_3O_4; thin splinters fusible to black magnetic glass.
3. Limonite; streak yellowish-brown; gives off water when heated; generally mammillated, botryoidal, or stalactitic, also compact or earthy; colour various shades of brown, from yellowish-brown to nearly black; before the blowpipe, as gœthite. The earthy varieties form yellow and brown ochre. The gœthite is found in very insignificant quantities incrusting the other two oxides.

By far the larger portion of the ore here in the three solid beds consists of limonite. The clayey ore is a mixture of yellow and red ochre, and is of no very definite composition. The red hæmatite is generally found in the interior of the lumps of ore, while the hydrated oxide forms a crust of greater or less thickness, being sometimes quite thin. The only varieties of red hæmatite I have yet seen here are the compact and the red ochre.

The gœthite occurs crystallised in prisms and tables, coating stalactites of limonite, and in cavities of red hæmatite or of the sandy rock.

The varieties of limonite are—

1. Compact.	2. Fine stalactites.	3. Mammillated.
4. Botryoidal.	5. Fibrous crusts.	6. Yellow ochre.

The forms assumed by the stalactitic limonite are very much varied, sometimes long and regularly tapering, sometimes short and irregular, or broad and smooth, or in small pear-shaped forms;

occasionally on the floor of a cavity are seen stalagmites rising to meet the stalactites above, and these stalagmites are short and broad, just as they are in limestone caverns. Crystals of quartz occur on these floors, generally lying flat, and sometimes they have groups of crystals of gœthite on their upper flat surface, a mode of occurrence which I have not seen in the quartz crystals on the stalactites above.

The minerals associated with the iron ore are quartz and sulphate of barium.

The quartz occurs disseminated through the hæmatite, filling up small cavities of quite irregular shape, and also in regular crystals on the surface of the stalactites in the cavities.

I have not yet seen any amethystine or purple quartz in this deposit, nor any large crystals, though the finest amethystine quartz in England has been found in Providence iron mine, at Ashton.

There are, however, here some very interesting crystals, though of small size. These are clear quartz crystals, in the interior of which are seen perfect models of the crystals of an opaque pale yellow or orange colour, the formation of which may be explained as follows:—

At some period when the quartz crystals were smaller, an excess of iron was introduced by the water flowing through the cavity, and this deposited a thin coating of hydrated oxide on the crystals already formed; this coating, however, was not sufficiently thick to affect the growth of the crystal, and as the water cleared, successive layers of colourless quartz were added till the crystals grew to their present size.

As a rule, the silica has been deposited after the iron; for the crystals generally adapt themselves to the stalactites, being fixed on to them, and in some cases a crystal in growing has met and enclosed the end of a stalactite already formed. The crystal sometimes is bifurcated, and terminates in a double instead of a single pyramid, leaving the stalactite between the two pyramids. This rule is not, however, invariable, for cases occur in which a stalactite growing downwards has met a quartz crystal and has been thrust more or less out of its course.

The quartz crystals attached to stalactites are generally hexagonal prisms terminated at each end by a pyramid; often, however, they are attached to the stalactite by one end of the prism. Cavities occur in the sandstone also lined with quartz crystals very short and crowded together, owing to the abundance of silicious matter in solution.

Some of the crystals are so transparent that they are seen with difficulty, but the majority reflect white light from some part of the interior.

The sulphate of barium occurs in small, thin, flat tables, sometimes pure white, but more generally reddish, owing to the presence of iron. It is found in the small cavities which abound in the ore, and also in the sandstone matrix.

The next point to be discussed is, how the ore was deposited as we now find it. It is clear that the stalactites could only have been formed by the action of water containing iron in solution, but this is equally true of the whole mass of iron ore. The question then arises, whether these beds of hæmatite were deposited at the same time as the interstratified beds of sandstone and clay, or whether they have been introduced since. The mode of occurrence of hæmatite deposits in other places, makes it almost certain that the latter is the true hypothesis; for these deposits are constantly found filling up large cavities or rents which cut the rocks at all angles, and are in no way interstratified as the beds are here. These veins or pockets are especially common in Carboniferous Limestone, and the explanation given in these cases is as follows:—Surface-soil always contains a certain portion of carbon dioxide, due to the oxidation of decaying vegetable matter. Rain falling on the soil takes up some of this carbon dioxide, and the water collecting in streams then has the power of dissolving limestone, forming bicarbonate of calcium. When the water runs for ages between the joints of limestone rocks, large cavities are thus formed—in fact, the latest explanation offered of the gorge of the Avon is, that it is a great cavern thus formed of which the roof has fallen in. Faults also produce rents in the rocks. Carbonate of protoxide of iron, $FeCO_3$, is also soluble in water containing carbon dioxide; but this carbonate is very unstable, like all salts of the protoxide of iron. The iron is very readily oxidised to the state of sesquioxide, Fe_2O_3; and when solutions containing these sesqui-salts are exposed to heat or pressure, they deposit either basic salts or, if the heat and pressure are sufficiently great, hydrous oxide of iron (limonite), or even anhydrous or red hæmatite. If, then, water charged with carbonate of the protoxide flows through these cavities, however produced, basic salts or the hæmatites will be deposited on the sides, and the basic salts will subsequently yield up their acid and leave hæmatite behind. As these rents are often deep under ground, the requisite heat and pressure are easily supplied. The fact that the anhydrous oxide is found in the centre of the lumps may perhaps be thus explained. The effect of the heat alone would have been to convert the whole mass into anhydrous oxide, driving off the whole of the combined water; but the outside of the lumps being in contact with the porous moist sandstone, retained the water to a certain depth.

The further question arises, how the cavities in the sandstone

rocks were formed which are now filled with ore; as the two principal hæmatite beds consist mainly of ore, we cannot suppose these open spaces to have been formed when the sand was originally deposited. In the Pennant grit at Portishead it is common to find cavities, formed by the decay of plants buried when the strata were deposited, now filled with oxide of iron. The cavity and the iron, however, distinctly show the form of the original plant. This explanation is not open to us, because there are here no impressions of fossils, and it is impossible to conceive of such a quantity of vegetable matter having been buried at regular intervals on an open shore.

It is therefore probable that the material which originally filled these cavities was limestone, for we have already seen that limestone can be dissolved by water containing carbonic acid, and all sandstone rocks are easily permeable by water. The difficulty is, that we should naturally expect to find traces of the limestone preserved here and there; but we find nothing of the kind, as far as I know. This difficulty is lessened, if we consider the length of time at our disposal for the complete removal of the limestone, amounting, perhaps, to millions of years. In illustration of the power of water to permeate sandstone rocks and remove carbonate of lime, I exhibit a specimen of sandstone from the upper limestone shales, just below the millstone grit, in which crystals of carbonate of lime were formed by segregation. These have subsequently been entirely removed, leaving only the casts of the double pyramids of calcite. Assuming, then, that the material removed was limestone, the next question is, whether the cavities were all formed first, or whether the two operations of removal and deposition went on simultaneously.

The existence of stalactites proves that the cavities were formed before the stalactites, but proves nothing about the date of the lining of the walls.

Some of the cavities in the hæmatite are divided into an upper and lower chamber, by a floor of hæmatite, which has stalagmites on its upper, and stalactites hanging from its lower surface, while the central part is compact limonite or red hæmatite.

If the cavities in the sandstone had existed before the introduction of any iron, it is impossible to explain the formation of these floors; for the deposit must have been made on the sides, and stalactites would have hung down the whole length of the cavity. In such cases it appears that the limestone was cut through the middle, probably by a joint through which the water trickled and deposited the compact oxide in a flat sheet; the work of removal, however, proceeded at a more rapid rate than that of deposition, and thus cavities were left above and below, which afterwards

were lined with mammillated, botryoidal, and semi-crystalline fibrous limonite, and partially filled with stalactites.

I have observed that in all cases the stalactites hang perpendicular to the actual horizon. As the cavities in which they occur are in beds dipping at an angle of 48°, this conclusively proves that the beds were tilted into their present position before the iron was introduced.

This observation is not limited to the stalactites, but also applies in many cases to solid lumps of hæmatite penetrated by veins of quartz, which are also perpendicular to the horizon.

If then, as seems most probable, the overlying horizontal beds are of Triassic age, and the lumps of hæmatite contained in them were derived from the denuded millstone grit, we can fix the date of the introduction of the iron ore. It must have taken place during the Permian and Bunter Sandstone periods, when this part of the country was dry land, and denudation was wearing down the hills to their present level.

The Coal Measures were originally deposited on the top of the millstone grit, and then began the series of movements which ended in tilting the whole set of older formations into their present inclined position. The Coal Measures of course went up with the rest, forming the summits of hills of very considerable height; but denudation set in at once—rain and rivers began the work, and then the land sank beneath the level of the Liassic and Oolitic seas, which helped to complete the ruin of the ancient hills. To account for the hæmatite in these hills, we need, in the first place, water highly charged with carbonic acid percolating through the rocks, and this is best supplied by rain-water sinking into the hill-sides and running down between the joints; secondly, this water must pass over beds of carbonate of iron, and this substance is supplied in abundance by the clay ironstones of the Coal Measures, which are a mixture of clay and carbonate of iron, and frequently contain veins of the carbonate. The materials for the Triassic sandstones must have been derived to a great extent from the waste of the Coal Measure hills; and the thickness of the Triassic beds shows that very extensive denudation took place.

Resuming the whole subject, then, it seems probable that these beds of millstone grit originally contained limestone masses.

Rain fell on the Coal Measures on the tops of the hills, sank into the ground, becoming charged with carbonic acid, passed over carbonate of iron and became partly charged with it, but still retained enough acid to remove the limestone masses it met in the grit, while at the same time it deposited the iron ore as we now see it.

The fossils obtained from these beds are reserved for separate

notice. The most interesting among them is a specimen of a large worm, over two feet long, which bears a strong resemblance to *Nereites Cambrensis* of Sedgwick.

MEETING, October 9, 1872.

The President in the Chair.

The second meeting for the term was held on Wednesday, October 9, in the Chemical Lecture-room. Twenty-eight members were present.

The minutes of the last meeting having been read, the President announced the following donations: — British Shells, from Mr Wheeler, the Mall, Clifton; Shells, from Mr Wheeler, Clifton; the Greater and Lesser Ferns (from Scotland), by Rev. R. B. Poole; Crabs, Echini, Brittle-stars, Sand-stars, from Tenby, by J. G. Grenfell, Esq.; a Twig incrusted with carbonate of calcium, from West Indies, by Darling.

The President announced the election of Teague, Peck, J. Evans Tomasson, Mordaunt, and R. M. Johnston as members of the Society. He then called on W. A. Smith, O.C., to read his paper on 'Catalysis,' which was illustrated by many effective experiments.

The President thanked Smith in the name of the Society for his paper; and congratulated the Society on the fact that two of the members present, W. A. Smith and W. Wood, had lately gained scholarships at Oxford, and expressed the good wishes of the Society for the future success of the two scholars at the University to which they were immediately going.

The following Heads of Sections were elected:—For Zoology, Allen; Entomology, Rev. J. Greene; Archæology, J. Jose, Esq.; Geology, J. G. Grenfell, Esq. The President proposed that the Chemical and Physical Sections should for the present unite their forces. This was seconded by R. M. Johnston, and carried. For this section Duncuft, proposed by Allen and seconded by A. Darley, was elected.

W. Wood, O.C., proposed by A. Darley and seconded by Duncuft, was elected a Corresponding Member. W. A. Smith, O.C., proposed by Stone and seconded by Johnston, was also elected Corresponding Member.

MEETING, October 25, 1872.

The President in the Chair.

The third meeting for the term was held in the Physical Lecture-room on Friday, October 25. Forty-six members and visitors were present.

The President called upon J. Atkinson, Esq., to read his paper on

THE USES OF A DEAD HORSE.

The horse (*Equus caballus*), of the family *Equidæ* and the order *Solidungula*, is an Old-World animal; but the precise limits of its earliest habitat cannot now be ascertained. Some part of Central Asia, however, appears to be the locality from which it originally spread. Mention is made of the horse in the Book of Genesis, and it is figured among the hieroglyphics of Egypt, so that its subjugation to man dates from the earliest times.

The Persians, Greeks, and Romans were all fully aware of its great value, and we find it extensively used among them, particularly for the purposes of warfare.

At the present time this all but indispensable animal is distributed through the greater part of the world, having been introduced by man into the various regions into which he himself has penetrated, excepting, of course, those where the climatal influence is adverse to its existence.

In the vast plains of America immense herds roam in a wild state, the descendants of comparatively few individuals which either escaped from or were let go by Europeans. Leaving out of question the number of varieties which have been introduced by cross-breeding, careful selection, and training, as well as the peculiar aptitude of different kinds for different purposes, and the successive phase each one may pass through in its checkered existence, let us consider the various useful purposes to which the several parts of the dead horse are applicable. This will be found to be a much more interesting subject than it would at first sight appear to be.

Strong efforts have been lately made to induce us to augment our supply of animal food by the introduction of horse-flesh; and indeed this has been for some time a by no means scanty article of diet among our Continental neighbours. Whether hippophagists will ever succeed in overcoming the prejudices of English stomachs remains to be seen; but there can be no doubt that if, as they tell us, the flesh of the horse is fully equal to that of the cow, it would be a very beneficial addition to the meals of the

labouring classes, at all events. Judging from the accounts of those who have joined in horse-flesh banquets, there can be no objection to the use of this new article of food on the score of unpalatableness; and as it contains the same elements as meat derived from the usual sources, there can be nothing to object to on the score of nutrition.

In giving an account, therefore, of the uses of the dead horse, we may put down its flesh as an article of diet for its masters. This, however, will apply to comparatively few, since the majority of horses die from accidents or disease, are worn out by old age, or carried to the knacker's yard to be disposed of as being past service. The flesh of these latter is not wasted, but, unless specially unfitted for the purpose through disease, &c., serves as food for cats, dogs, pigs, &c.; and it is even suggested that it partly finds its way into that *omnium-gatherum* of all odds and ends—the sausage. The tongues, too, are said to be preserved, and sold at a high price as reindeer's tongues. The remainder of the flesh, together with that which is deemed to be totally unfit for food in any shape, is boiled down for the sake of the fat which it contains.

In the American pampas, where thousands of these animals are slaughtered each week, the fat together with the hide, bones, and hair are the only objects looked to, the carcass being discarded as worthless. It may be as well here to state that a dead horse in England varies in value from 20s. to 60s., and weighs from 500 lb. to 1100 lb. Dismissing now the flesh, we come to the solid part or framework of the body, *i.e.*, the *bones*.

I think it would be difficult to find any substance which is applied to a greater variety of purposes than bone. Whether we want a paper-knife or the handle of a penknife, a set of chessmen or a tooth-brush, a button or the knob of a cane, whip, or umbrella, or a hundred other articles of everyday use, bone supplies our necessity. But, before being applied to these manifold purposes, certain of its constituents are extracted, and in order to understand this properly we must enter somewhat into the chemistry of the matter. Most people have noticed, I suppose, that roughly speaking a bone consists of two structures—a denser, harder, external part, and an inner, softer, spongy part. There is no clear line of demarcation between the two portions, one shades off insensibly into the other. This will be more readily seen in the flat bones. In the long bones, such as those of the legs, the interior is filled with marrow. This is one division of the osseous or bony structure; but there is another which requires some treatment to make it evident to the eye. If you take a bone and heat it in an open fire to a white heat, you will find on removing it

that a great change has taken place. It has become whiter, more brittle, and very much lighter; but has not lost its original shape and bulk. This change is owing to the removal of the organic or animal part of the bone; and what is left is the inorganic or mineral part. If, instead of putting the bone in the fire, you were to digest it with an acid, such as nitric acid (*aqua fortis*) or hydrochloric acid (spirits of salt), the mineral part would dissolve, and the organic part would be left behind as a gelatinous, flexible mass, still retaining its original shape.

Hence we find that a bone consists of organic and inorganic matter; and in full-grown bones the proportions of the two would be one-third of the former to two-thirds of the latter. In younger animals the organic exists in greater proportion; in older ones the reverse is the case. Berzelius gives the following analysis of osseous structure:—

Animal matter, ...	33·30
Phosphate of lime (bone earth), . .	51·04
Carbonate of lime (chalk), . .	11·30
Fluoride of calcium (Derbyshire spar), .	2·00
Magnesia (phosphate, &c.), . .	1·16
Soda salts, ...	1·20

Now the animal matter contains in addition to its gelatine a considerable amount of fat; and the manufacturer's first care is to get this fat out. For this purpose the bones are simply boiled. The uses of the fat will come under the head of the fat proper, and need not be further mentioned at present. The larger bones are now handed over to the turner, to be manufactured into articles such as have already been spoken of. The smaller ones, together with the dust and chips of the factory, and the pieces punched out of the holes of buttons, &c., are carefully collected, and find several applications. Some parts are digested with steam under a great pressure and made to yield up the gelatine, which is the substance from which we derive the jelly for our tables, the wrappings of sweetmeats, glue, size for stiffening straw hats, &c. Another portion, being burnt in close vessels, is converted into animal charcoal (bone-black or ivory-black), and after the removal of the phosphate of lime by means of hydrochloric acid, is extensively used as a decolouriser and deodoriser. It is by means of this substance that white sugar is produced, raw sugar being of a dirty-brown colour. From its power of removing foul effluvia, it is an excellent thing for purifying the air from sewers, sick-rooms, &c. One of the most extensive applications of bone still remains to be spoken of—the utilisation of the phosphoric acid. Bone-earth or phosphate of lime forms no less than one-half of the constituents of bone. This phosphate is a compound of three

equivalents of lime to one of phosphoric acid; the acid, again, is a compound of phosphorus and oxygen. The process by which the phosphorus is separated is rather complicated; but the essential operations are the removal of the lime by means of sulphuric acid (oil of vitriol), and next of the oxygen by distillation with charcoal.

Phosphorus is of great value to the chemist, because it assists him in several important experiments—as, for instance, in separating the nitrogen from the oxygen of the atmosphere, by which means he is enabled to tell us the constituents of the air we breathe.

But a much more extensive application of it is in the part it plays in the manufacture of lucifer matches. Here we may observe that the word phosphorus is derived from two Greek words, and lucifer from two Latin words of precisely the same signification—viz., light-producer. The composition in which the match is dipped consists of a mixture of phosphorus, sulphur, and nitrate or chlorate of potash; so that substituting charcoal for phosphorus we have the ingredients of gunpowder. There are two kinds of lucifers now manufactured: in one the matches are dipped in the composition as above stated, and will explode with rubbing on any dry, rough surface; in the other case the phosphorus is put on a separate surface, such as a piece of paper pasted on the box, and then the matches will only ignite when rubbed on this surface; in this case the phosphorus is in what is called an allotropic state, that is, it has undergone certain changes by being kept at a great heat for a long time; among other modifications it assumes a reddish colour, and is no longer spontaneously inflammable.

The most extensive, however, if not the most important use of bone-earth, is owing to the power it has been found to possess of fertilising the lands to which it is applied as manure. Its ordinary name in this case is superphosphate. Thousands of tons of this manure are produced annually in England. To change the bone-earth into superphosphate, the bones are crushed and mixed with a certain proportion of sulphuric acid, the effect of which is to withdraw a part of the lime; the remainder is superphosphate. Let us now try to understand the reason of this particular manure being so valuable to us. We have already seen that the bones of animals contain a large amount of phosphorus, but there are other tissues of the body in which the same substance is found—the brain and the nervous system, the milk and the blood.

Whence does the system procure this phosphorus? Evidently from the same source as that from which it draws its other constituents—the food. We use the bodies of animals for food, and their bodies in turn are built up from their food, and thus we reach

the vegetable kingdom as the ultimate source of the elements of our bodies. If, then, we are constantly removing the phosphorus in the form of phosphates from the soil by means of plants, we must necessarily in course of time exhaust the powers of our fields, unless we return to them the constituents we have taken away. This we are enabled to do by means of superphosphate or bone-manure. Not that this is the only source from which phosphorus is obtainable; several others offer themselves to us.

In Bohemia, and more especially in the province of Estremadura, in Spain, a mineral called apatite, consisting principally of phosphate of lime, occurs in large quantities, and might be made a source of immense wealth to those countries if properly developed. The same mineral is found in small quantities in Cornwall and Devon. Phosphate of lime abounds also in the bodies called coprolites, which are generally regarded as the dung of fossil animals. They are found in large quantities in the Lias formation in England. Phosphorus thus affords a very good illustration of the circulation of matter, or, as it is often called, the indestructibility of matter. Taken up from the mineral world by the plant; from that it goes to form part of the animal, and from the animal back again to the mineral world. And so it is with every other substance: nothing is ever lost in the economy of nature; it merely alters its place or condition, running on in one unceasing round from age to age. The identical atom of phosphate of lime which once formed part of the system of some huge saurian of the antediluvian world, may now form part of our own bodies, and centuries hence may again contribute its share to the formation of living beings like ourselves.

The *blood* does not find so many applications as the bone; but it is not wasted. I do not know whether it is ever used as the blood of bullocks is in clarifying sugar. The use of animal charcoal in the process of sugar-refining has been already mentioned; but before the charcoal is applied, blood is added to the sugar, and the mixture is then heated sufficiently high to coagulate the albumen of the blood. This entangles the coarser impurities, which are then skimmed off. The coagulation of the albumen by heat is exactly the same thing that takes place in boiling an egg. The white of the egg consists of albumen, which, as any one knows, sets into a firm mass when exposed to the temperature of boiling water.

The principal part of the blood, however, is handed over to the manufacturer of prussiate of potash, the substance which with a certain admixture of an iron salt forms Prussian blue, and is the base of the blue colours with which our clothes and other articles are dyed. There are two prussiates, called, from their

respective colours, red and yellow prussiate of potash. In order to obtain them we take, according to Dr Lankester on the 'Uses of Animals in Relation to the Industry of Man,' p. 155, 'three sets of substances:—1. Refuse of animal substances—blood, bones, hoofs, horns, &c., which yield nitrogen and carbon. 2. Old scraps of iron—refuse iron, shoes from dead horses, rusty nails, and worn-out iron hoofs. 3. Potashes, Montreal ashes, the refuse, if you like, of hewn trees; and these supply the potassium. Now, when these things are exposed to heat together, they arrange themselves in this way: the iron unites with the carbon and nitrogen in the form of cyanogen, forming ferro-cyanogen; and this compound unites with the potassium, forming the ferro-cyanide of potassium; and this is what these salts are—ferro-cyanides.'

Passing over the intestines and the tendons, of which the former are used to cover sausages, while the latter are boiled down to form jelly, glue, &c., we will go on to the *hide*.

This is to us a most important part of the horse, since it is the source, in common with that of other animals, of leather. What a strait we should be in if our supply of leather should be exhausted! Of course we might to some extent find a substitute for it, and indeed such a substitute is extensively used in the form of gutta-percha and india-rubber; but neither these, nor any other material with which we are acquainted, answers so perfectly as leather for many purposes. Great efforts have been made to apply india-rubber to the manufacture of mill-bands, for conveying motion from one wheel to another, but it does not equal leather. Then, again, our shoes and the harness for our horses are made of leather, and it would be a difficult matter to procure an equally efficient material for these purposes. A great part of the body of carriages, trunks and portmanteaus either partly or altogether, the hose for our fire-engines, the backs of books, the covers of chairs, picture-frames, and a hundred other necessaries or comforts of life, depend on the leather trade. What, then, is leather? Well, chemically speaking, it would be said to consist of a tannate of gelatine and albumen, the former predominating. Some say, however, that it is not gelatine but ossein which forms so large a part of the skin, since a skin is not soluble in water as gelatine is.

Probably most people have been at one time or other in a country where oak-trees are abundant, and they have very likely seen numbers of these trees, after they are cut down, stripped of their bark, which is piled up in heaps close to them. This bark is the principal source of the tannic acid which is used to convert the hide or skin into leather. The process by which the change is effected is called 'tanning.' The ordinary method of tanning is to put the hides into a pit with alternate layers of oak-bark,

and leave them there till they become leather. They may remain in the tan-pits sometimes as long as two years. There are other and quicker means of bringing about the desired change; but these, as a general rule, depend on the same principle, *i.e.*, the addition of tannic acid to the skin, with which its gelatine and albumen combine.

Chamois or buff leather is an exception, oil being substituted for the tannic acid. Alum can also be used for the same purpose. What an astonishing difference between the easily-decomposed skin and the tough, durable leather into which it is thus converted! The clippings of hides, the odds and ends of leather, as well as fragments of bones and tendons, are boiled down to furnish glue and the gelatine which has already been mentioned. From the *hide* let us turn to its appendage the *hair*.

The plumes of our soldiers' helmets, and suchlike military decorations, use up a large quantity of the long hairs of the tail and mane. Another portion goes to the stuffing of chairs and mattresses, and for the manufacture of haircloth, with which our chairs and sofas are often covered. A small part is made into fishing-lines. The short hair is chiefly used for mixing with lime to form mortar, but a good deal goes to the maker of Prussian blue.

At one time the manufacture of crinolines consumed a part of the best hairs, for the real article of dress so called was made, as the name imports, of hair; though, to meet the wants of numbers who could not afford such a high-priced luxury, whalebone, steel, cane, &c., were extensively used.

The *hoof*, and its protector the *shoe*, next claim our attention. The solid part of the hoof goes to the turner to be made into buttons and articles of a similar kind; of the remainder a part is converted into gelatine, glue, &c., while the rest goes to the Prussian-blue manufacturer. The shoe and nails can of course be used for the many purposes to which old iron is generally applied; but the nails have a value of their own, being in high repute in the manufacture of gun-barrels. A rather curious application of old iron may be quoted from an article in the *Quarterly Review* for April 1868, 'On the Use of Refuse:'—'Scraps of iron may be made useful in securing the copper that runs away in the streams washing veins of copper-pyrites. In the Mona Company's mines in North Wales old pieces of battered iron are placed in tanks into which these streams are collected; the copper quickly incrusts the iron, and in process of time entirely dissolves it, so that a mass of copper takes the place of the iron.' Cart-horse shoes are often used among the rural population in place of quoits.

The last part of the dead horse that requires to be spoken of is the *fat*. It would be a difficult and tedious matter to attempt to give anything like a full account of all the uses of fat. One or two may be noticed. Besides the fat proper, a large quantity, amounting to many tons a week in London alone, is extracted from the crushed bones by boiling them. This bone-fat is in great request for making pomatum, bears'-grease so called, and the superior kinds of toilet soaps. The coarser fat is converted into the commoner soaps and into candles.

The introduction of spermaceti and paraffin as light-producers has of late driven tallow to a great extent out of the field.

The quantity of fat derived from a well-conditioned horse is about 50 lb., worth about 6d. a pound.

Thus we have found that a horse is quite as useful when dead as he was when alive. The popular saying, that when a thing is dead there is an end of it, is quite as untrue as many other popular sayings. We have shown that it certainly is not true of the horse, and we may even go so far as to say, that 'man's friend' when dead is only just beginning to show how useful he is.

To sum up the short sketch we have given, let us see what part a dead horse plays at a small supper party, for there he appears in as many shapes as Proteus of old. The chairs and sofas are probably indebted more or less to his coat for their stuffing and their covers. The room may possibly be lit with candles to which he has contributed his share; and to him may be due the salt and mustard spoons, as well as the handles of the knives and the napkin rings. If he does not furnish the 'roast or boiled,' he may at all events have had a share in the jellies and sausages.

For the toilet-table of the guests he may have provided the scented soap and pomatum (or bears'-grease, if you like that name better); the tooth-brush owes to him its handle, and probably the tooth-powder has been made from his burnt bones, since under the name of charcoal or charcoal-paste, bone-black does duty in cleansing the teeth, which teeth the horse has helped to produce in the shape of superphosphate applied to the fields; in this latter form, also, he assisted in growing the wheat from which came the flour for the tarts and puddings. The young gentleman's cane and the young lady's parasol are under obligation to him for their ornamental handles. The different parts of the tables and chairs are fixed together with glue made from his tendons, bones, and skin. Perhaps he has helped to embellish the walls in the way of leather for the binding of the books and the frames of the pictures, since these latter are often made of leather. Some of the clothes, also, may owe their colour to the Prussian blue, which has derived part of its constituents from the horse; and the

buttons on some of the coats may have been stamped out of his hoofs. Enough, however, has, I think, been said of the useful properties of the dead horse to induce us to be grateful to him for his many good qualities, and to treat him with kindness while alive.

Another lesson we may also derive from what has been said, *i.e.*, not to discard and throw away anything as waste till we have failed to turn it to some account; and even if we fail to do so, it may still have a hundred useful purposes in it, which further research may one day turn to good account.

Mr Atkinson was received with much applause, which was often repeated throughout his paper. The President and Gibbons spoke on the paper. The President proposed a vote of thanks to Mr Atkinson, seconded by G. Dakyns, and carried unanimously.

At a subsequent Committee meeting A. George was elected a member of the Society.

MEETING, November 7, 1872.

The President in the Chair.

The fourth meeting for the term was held on Thursday, November 7. Thirty members were present.

Donations announced:—Tertiary Fossils from Lyme Regis, also from Bognor Rock, Swanage, Chapman's Pool, near St Albans, Barton Shells (in all about 100 specimens), by A. Leach, O.C.; Cornish Minerals (43 specimens, comprising Copper and Tin Ores, Quartz, Fluorspar, Wolfram, Bismuth, Oxide of Uranium and Cobalt Ores, &c.), by Carus-Wilson; Shells from the Carboniferous Limestones, found and presented by J. G. Grenfell, Esq.; he also presented a Fossil (undescribed), found by himself in the Millstone Grit, and strongly resembling *Nereites Cambrensis* (Sedgwick).

J. A. Gibbons read a paper on the 'Strasburg Cathedral,' exhibiting some prints and photographs of the Cathedral, astronomical clock, &c. The President and W. Paul, O.C., spoke at some length. A vote of thanks to Gibbons was proposed by the President, and was carried unanimously.

MEETING, NOVEMBER 21, 1872.

The PRESIDENT in the Chair.

The fifth meeting for the term was held in the Physical Lecture-room on Thursday, November 21. Thirty-five members and visitors were present.

A donation of Clifton Minerals from the President was announced.

The President then read a paper on the 'Minerals of Clifton and the Neighbourhood,' exhibiting a large number of specimens.

CLIFTON MINERALS.

1. Coal; near Bristol.

2. Petroleum or Naphtha; a compound of carbon and hydrogen; in cavities in the Carboniferous limestone; Hotwells and Black Rock, Avon section.

3. Bitumen or Asphalt; also a hydro-carbon; in small quantities in Carboniferous limestone; in sparry cavities, Avon section.

4. Casts of crystals of rock salt in mud hardened into shale; Trias, Aust.

5. Fluor spar; Calcium Fluoride; rare; only in small blue or purple crystals in sparry cavities in Carboniferous limestone; Black Rock and Great Quarry, Avon section.

6. *a*, Calcite; Calcium carbonate; large crystals in veins and joints of limestone, Avon section; in cavities in Dolomitic conglomerate on which the College stands; in geodes, Westbury and Mendip Hills; and small crystals in the Lias, Horfield. *b*, Stalactites at Cheddar; stalactitic crusts, forming the so-called bacon-stone, at Cheddar and the Avon section. *c*, Rock Milk; closely resembles chalk; Eaglestaff's Quarry, Avon section. *d*, Marble, some of the limestones of the Avon section; the Cotham marble or landscape-stone is found in the Lias at Cotham and elsewhere. *e*, Anthraconite or fetid limestone; gives a fetid smell when struck; probably contains sulphuretted hydrogen; Black Rock, Avon section.

7. *a*, Selenite; Calcium sulphate; single and twin crystals at Aust Cliff. *b*, Gypsum, alabaster and satin-stone; New red marls, Aust and Pembroke Road.

8. Heavy Spar; Barium sulphate; small crystals associated with quartz and hæmatite, iron mine at Royal York Crescent; variety resembling old bones, Avon section, under Durdham Downs; also found in veins in Carboniferous limestone, Avon section.

9. Celestine; Strontium sulphate; splendid crystals in red marls and sandstone at Pyle Hill; fine radiating variety in Dolomitic conglomerate, Pembroke Road; found also in new red marls, Ashton, and lining the faults at Aust Cliff; a soft variety, which forms an impalpable powder in the hand, is found near the Pembroke Road, along the railway.

10. Dolomite; Calcium and Magnesium carbonate; Dolomitic conglomerate; not crystalline.

11. Quartz; Silicon Dioxide: *a*, Rock Crystal; clear crystals; Royal York Crescent Iron Mine with hæmatite; Upper limestone shales across Suspension Bridge; Ashton; Winford, very fine; geodes at Cheddar and

Westbury ; enclosing lance-head crystals of gœthite, across the Suspension Bridge, and Winford ; also in geodes ; enclosing yellow or red oxide of iron, and therefore called ferruginous quartz, at Royal York Crescent ; smoky quartz, Winford. *b*, Amethyst ; colour supposed to be due to iron ; splendid crystals, formerly at Providence Iron Mine, Ashton ; amethystine quartz still found there and at Winford. *c*, Chalcedony ; Cheddar in geodes ; Dundry in oolite. *d*, Jasper ; ribbon jasper, said to have been found at Tortworth ; pseudo-morphous after fluorspar, near Bristol.

12. *a*, Talc ; Magnesium Silicate ; foliated at Woodford Bridge in basalt. *b*, Steatite or Soapstone ; same locality.

13. Basalt ; mixture of Augite and Felspar ; Augite ; Calcium, Magnesium and iron silicate : Felspar ; Aluminum and Potassium silicate ; Woodford Bridge.

14. Prehnite ; one of the Zeolites ; hydrous silicate of Aluminum, Calcium, with a little iron ; also at Woodford Bridge, but not of late years.

15. Gold ; in minute quantity at Clevedon, according to Mr W. Stoddart.

16. Anhydrous oxide of iron. *a*, Specular Iron ; in crystals ; Lias near Bristol. *b*, Red Hæmatite ; massive ; abundant at Royal York Crescent Mine in Millstone Grit ; common in Carboniferous limestone, especially the upper part ; Providence Mine, Ashton ; Winford ; Clapton in Gordano ; pseudo-morphous after calcite, Avon section. *c*, Red Ochre ; red hæmatite mixed with clay ; accompanies the above generally.

17. Limonite, or Brown Hæmatite ; hydrous oxide of iron ; $Fe_2O_3(H_2O)_2$; *a*, massive ; with red hæmatite. *b*, stalactitic ; very fine at Royal York Crescent and Clapton. *c*. Yellow ochre ; earthy ; in small quantities occasionally at the mines.

18. Gœthite ; hydrous oxide of iron ; Fe_2O_3, H_2O ; crystals on limonite, Clapton and Royal York Crescent ; in sparry cavities of limestone, Black Rock ; penetrating quartz, Ashton, Winford ; in geodes, Cheddar.

19. Iron Pyrites ; iron di-sulphide ; cubes in coal at Ashton ; Rhœtic beds, Aust ; Lias, Horfield ; disseminated through shelly limestone, Black Rock.

20. Clay Ironstone ; mixture of clay and carbonate of iron ; Coal Measures near Bristol.

21. Vivianite ; Iron phosphate ; said to have been found in Alluvium near Clifton.

22. Melanterite ; Iron Sulphate ; Fuller's Earth pits, Widcomb Hill, Bath.

23. Pyrolusite ; Manganese di-oxide ; in a cutting on the Downs near the College.

24. Manganite ; hydrous oxide of Manganese ; Churchill, Mendips, Trias, Clevedon, near Royal Hotel.

25. Galena ; Lead sulphide ; curiously flattened octohedral crystals in veins of calcite traversing limestone, Avon section, at foot of new zigzag ; Kings Weston Down ; Mendip Hills ; Clevedon, in Trias.

26. Mendipite ; chloride and oxide of lead ; only in Mendips ; not for the last twenty years.

27. Malachite ; Copper carbonate ; Triassic beds, Clevedon, near Royal Hotel.

28. Calamine ; Zinc carbonate ; Shipham, Mendips.

29. Smithsonite ; Zinc silicate ; Shipham.

30. Blende ; Zinc sulphide ; Shipham.

25 NOV. 1916
BRITISH MUSEUM

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Scientific Society,

FOUNDED JUNE 25, 1869.

"VIRESQUE ACQUIRIT EUNDO." - Virg. *En.* iv. 175.

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1875.

PRICE 3/6.

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1875.

PREFACE.

At last, after many delays and difficulties, our new number appears, testifying, however, it is to be hoped, that the Society is still in a flourishing condition, and is still doing the work for which those who went before us established it.

It has been said, with much truth, that the value of a Scientific Society depends on the value of the original papers contributed to it, but we would claim for our Society that it be judged by another test, namely, whether it is encouraging its members in the study of science, and training them in those habits of observation which will hereafter enable them to do good original work. We hope that such is the case; we find old members of the Society coming back and reading papers to us, or sending us specimens from their neighbourhoods; and our present members are working steadily, each at his own special subject. It is a matter also of congratulation that such a distinguished member of the scientific world as Mr. Francis Fry should have consented to read to us the paper which is printed in this number, but of the interest of which those who did not see the beautiful experiments by which it was illustrated can form but a poor idea. The Society is also in a flourishing condition as regards both numbers and funds.

Many valuable additions have been made to the Society's collections of late—in particular Mr. Tuely's magnificent gift of a collection of exotic Lepidoptera; and a perfect collection of British birds' eggs, from H. Bernard, O.C., must be mentioned. The new Museum is now ready, and offers a good opportunity to those who are well-disposed towards us to bring us their contributions that it may be filled with good and interesting objects. There are some things of

which we are greatly in need, which we may take this opportunity of specifying. Our collection of Sponges is very small indeed, as also is that of Echinoderms; and we should be very glad of a small collection of insects illustrative of the main types of the different orders. We have had a promise of a number of British Beetles to complete our collection. We want, too, more local collections. If in the coming term some members of the Society would work hard at collecting for us local insects or Mollusca, it would benefit all concerned.

It is to be regretted that a greater number of papers is not read by the members of the Society, it is always falling back on the honorary members for papers. This is not as it ought to be; if only a few more would thoroughly master some subject, and each give us the result of his own reading and observations it would render the Society's transactions more interesting, and help him in the habit of putting in order those ideas which are so often almost hopelessly confused in the brain.

Since the publication of our last number we have lost, by death, one of our best friends—the Rev. Charles Kingsley. From the earliest days of our Society he always took a deep interest in our welfare, his words of encouragement to us were some of the kindest and the wisest we have heard, his help some of the most efficient we have had. He is now gone, but his memory will ever remain with us, and his example and teaching will help us to go on in the path marked out for us, till we each of us learn the lessons he learnt, and love the things he loved.

G. H. W.

10th April, 1875.

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M. J. Barrington-Ward, B.A., F.L.S.
Rev. H. J. Wiseman, M.A.
Rev. J. Greene, M.A.
Rev. H. C. Watson, M.A., F.R.A.S.
C. J. Peile, B.A.
C. F. Rodwell, F.R.A.S., F.C.S.
Rev. B. Hartnell, M.A.
G. T. Atkinson, B.A., F.C.S.
T. T. Proctor, Esq.
J. Saunders, Esq.
F. F. Tuckett, Esq., F.R.G.S.
F. Black, Esq., M.D.
J. Perry, B.E.
Rev. H. N. Ellacombe, M.A.
Rev. E. Harris.
Rev. R. B. Poole, M.A.
J. Robinson, Esq., F.C.S.
Rev. J. Heyworth, M.A.
Prof. M. Lawson, M.A., F.L.S.
W. S. Paul, Esq.
J. E. Jose, Esq.
J. F. M. H. Stone, Esq.
W. A. Tilden, Esq., D. Sc.
Wm. Lant Carpenter, Esq., B.A., B. Sc., F.C.S.
J. A. Gibbons, Esq.
W. Becker, Esq., B.A.
H. S. Hall, Esq., B.A.

CORRESPONDING MEMBERS.

A. Cruttwell, Cardiff.
E. O. Ashby, Merton Coll., Oxford.
W. F. Howlett, Christ Ch., Oxford.
F. W. Shaw, Chorley New Road, Bolton-le-Moors.
A. W. Brodie, Sid. Suss. Coll., Cambridge.
H. H. Mogg, Pemb. Coll., Cambridge.
J. I. Fox, Clifton.
H. Proctor, Univ. Coll., Oxford.
C. T. Blanshard, Queen's Coll., Oxford.
E. Crosse, Exeter Coll., Oxford.
W. J. P. Wood, Magdalen Coll., Oxford.
W. A. Smith, Christ Church, Oxford.
C. L. Ivens, Christ Church, Oxford.
J. Whidborne, Christ Church, Oxford.

ORDINARY MEMBERS.

J. W. Bean.
J. Allen.
W. Stone.
A. L. Fell.
A. E. Darley.
J. Swinburne.
F. L. Cartwright.
H. C. Thomson.
G. H. Horsfall.
H. Moser.
A. G. Haines.
J. V. Izon.
P. Mordaunt.
W. J. Haines.
H. P. Marsh.
G. F. Travers.
H. G. Wells.
C. G. Wells.
R. F. Synge.
H. J. L. Evans.
J. Duncuft.
R. M. Johnston.
M. H. Maw.

R. Anderson.
C. L. Ivens.
H. D. Douglas.
W. A. Darling.
C. H. Firth.
W. Aspland.
T. R. Montgomery.
R. Donovan.
G. Forbes.
T. K. Twist.
J. S. Chitty.
J. Maclachlan.
H. W. Boswell.
F. Dun.
J. B. Campbell.
G. Dakyns.
H. Wills.
T. L. Jenkins.
G. Maw.
F. Fowler-Jones.
W. Baillie.
H. P. Burt.
W. Tomasson.

J. A. Moggridge.
A. George.
H. C. Jones.
J. Teague.
W. Sherring.
C. Browne.
Wansbro-Jones.
M. O. Norris.
R. A. Kyrke.
A. M. Callender.

JUNIOR SCHOOL.

H. N. C. Heath.
A. Cole-Hamilton.
V. E. Leonard.
F. C. W. Rideout.
A. Bethune.
C. G. Brittan.
G. L. Turnbull.
A. Younghusband.
W. Chubb.
W. E. Hill.

DIRECTORS OF SECTIONS.

Geology.....J. G. Grenfell, Esq.
Botany.....G. H. Wollaston, Esq.
Archæology.....C. L. Ivens.
Chemistry and Physics.....R. M. Johnston.
Zoology.....G. Dakyns.

Clifton College Scientific Society.

RULES.

I.—That this Society be called the "CLIFTON COLLEGE SCIENTIFIC SOCIETY."

Constitution.

II.—That the Society consist of Ordinary, Corresponding, and Honorary Members.

Officers.

III.—That the Officers of the Society consist of a President, Vice-President, Secretary, Treasurer, and Four Members of Committee, to be elected from and by Members of the Society, with the exception of the Secretary, who shall be chosen by the Committee from their own number. All Officers, excepting the President and Vice-President, to be elected terminally.

Management.

IV.—That the affairs of the Society shall be conducted by the above Officers.

Secretary.

V.—That the duties of the Secretary be, to keep a list of all the Members of the Society, and of all former Members and Benefactors, who may wish to receive the Transactions of the Society; to give notice of meetings and to keep a detailed report of the proceedings, as well as lists of Members and Visitors present at each meeting. In the absence of the Secretary, the President may appoint any Member of the Committee to take minutes of the proceedings.

Treasurer.

VI.—That the duties of the Treasurer be, to collect all sums of money due to the Society, to receive all donations of money, and to disburse all sums of money payable by the Society out of the funds entrusted to him.

That the Treasurer furnish terminally a detailed account of the receipts and disbursements, to be audited by the Committee.

Members.

VII.—That the number of Members be seventy, of whom ten shall be elected from the Junior School.

That Honorary Members be elected by the Committee, for two years only; but any Honorary Member re-elected after that period, be not required to pay any further subscription.

That Honorary Members, on the payment of the single sum of one guinea, or the annual sum of three shillings, shall receive the Transactions, post free.

That Corresponding Members be elected by the Society for five years; but that a Corresponding Member, on signifying to the Secretary in writing his desire to remain on the Society's books at the termination of that period, be allowed to do so.

That Ordinary Members be elected by the Committee.

That, on election, every Member of the Society shall sign his name in a Register (to be kept by the Secretary).

That a subscription be payable terminally by all Ordinary Members (the amount to be fixed by the Committee), but in no case to exceed Two Shillings and Sixpence for the Upper, and Two Shillings for the Junior School.

That Honorary Members residing at the College shall have all the privileges of Ordinary Members.

That all subscriptions must be paid between *the first and second meetings of the term*, and that any Member retiring from the Society be required to pay all subscriptions due.

That, under penalty of expulsion from the Society, all Ordinary Members be required to attend two-thirds of the meetings in each term, except for reasons deemed sufficient by the President.

That Corresponding Members shall have the privilege of taking part in the proceedings of all meetings that they may attend, but shall not be liable to any subscription.

Sections.

VIII.—That Sections be formed for the more accurate study of the different branches of Science, and that the Directors of these Sections be chosen terminally by the Society.

That the Sections shall hold meetings as often as may seem fit to their respective Directors, at which any Members of the College, with the sanction of the Director, may attend.

That the Directors of the different Sections be invited to communicate to the Society any matters of interest which may have come before them, and that such communications be made at the commencement of each public meeting, at least one day's notice having being given to the Secretary.

That reports of the work done in each Section shall be handed by the Directors to the President before the final meeting of every term.

That the President and Secretary be *ex officio* Members of every Section, and shall receive notice of all sectional meetings.

That not more than ten Members be permitted to join any one Section.

That all elections in each of the Sections be vested in its Director, who may, at his discretion, remove any Member from it, subject only to the approval of the President.

That there shall be Six Sections : Botany, Zoology, Chemistry, and Physics, Entomology, and Archæology.

Meetings.

IX.—That ordinary Meetings of the Society be held at least once a fortnight during term, but that the President be empowered to call extraordinary meetings and to postpone the regular meetings.

That Fifteen Members shall form a quorum.

That the order of business at each meeting shall be arranged by the President.

That Members be requested to bring for exhibition at the meetings of the Society specimens of Natural History, and illustrations of Natural and Physical Science in general.

That Members be invited, when they may have it in their power, to present donations and specimens to the College Museum, such donations to be acknowledged at the meetings, and in the Society's Transactions.

That in all cases of equality in voting, the President shall have a casting vote.

New Rules.

X.—That any Member of the Society have power to propose any new rule, or any alteration in an old one, provided the motion be seconded by another Member, and that notice of at least one week be given to the Secretary.

XI.—That no Member of the College, not a Member of the Society, be admitted to the Meetings without a ticket signed by one of the Committee.

Excursions.

XII.—That two Excursions be made every three weeks for the purpose of studying Natural History. That Members of the College, not in the Society, be allowed to attend on obtaining permission from the President; the number thus admitted not to exceed eight.

That all Members of the Society below the sixth form, who have not otherwise taken an active part in the business of the Society, be obliged to attend two Excursions in every term, under penalty of surrendering their places in the Society to qualified candidates.

TRANSACTIONS

OF THE

CLIFTON COLLEGE SCIENTIFIC SOCIETY.

MEETING, December 5th, 1872.

The President in the Chair.

The Sixth Meeting for the Term was held in the Physical Lecture Room, on Friday, December 5th. The President announced the following donations:—Indian Shells from Miss Douglas, and Fossils from himself. About forty-five Members and Visitors were present.

The President then read a report on the Barometer and Thermometer readings during the months of October and November, which had been kept by R. M. Johnston; he thanked Johnston for the trouble he had taken in keeping the record, and made some remarks on the unusual lowness of the pressure.

Abstract from the record:—

Mean Temperature for the 3rd Term, 1872.

* *Thermometers (in the Shade).*

1872.	In the last 24 hours.		Taken at 8.30 a.m.
	Maximum.	Minimum.	
October - - -	51°.70	42°.56	45°.75
November - -	49°.63	40°.76	44°.30
December - -	44°.95	36°.47	38°.87

* These observations were taken at 8.30 morning. The last column indicates the mean temperature during the month at that hour.

MEAN HEIGHT OF BAROMETER READINGS (not corrected).

1872.	Taken at 8.30 a.m.	At 3 p.m.	Date when lowest.	
October - -	29.186 inches	29.179 inches	17th	28.720 inches
November -	29.133 „	29.119 „	30th	28.108 „
December - -	28.882 „	28.893 „	1st	28.408 „

R. M. JOHNSTON.

The President exhibited a collection of Fossils dissolved out of limestone from the well-known Bryozoa beds of the lower limestone shales.

J. Allen (Treasurer), then read a paper on "Blood."

The Officers for next term were then elected as follows:—J. Allen was elected Treasurer, and Rev. J. Greene, J. A. Gibbons, J. Duncuft, and R. M. Johnston were elected for the Committee.

Before closing the meeting, the President, in the name of the Society, congratulated R. B. Don on obtaining the Brackenbury Scholarship at Balliol College, Oxford. R. B. Don thanked the Society, and expressed his regret at leaving it.

FIRST TERM, 1873.

MEETING, FEBRUARY 5TH, 1873.

The PRESIDENT in the Chair.

The first meeting of the term was held in the Physics Room, Sixty members and visitors were present.

The following donations were announced:—Fossils from G. Spencer Percival, Esq., C. H. Firth, and the President; Cornish Minerals from Carus-Wilson.

The President announced that Mr. Barrington-Ward's Medal had been gained by T. R. Montgomery, and that Mr. W. Stoddart had kindly promised a Lecture on "British Spiders."

Mr. W. Lant Carpenter (B.A., B. Sc., F.C.S.,) proposed by the President, and seconded by J. Allen, was elected an Honorary Member.

The Society then elected G. Dakyns and A. E. Darley, members of the Committee. G. Dakyns was afterwards elected Secretary.

The President, J. G. Grenfell, Esq., then read a paper on "Super-saturated Saline Solutions," illustrated with many experiments. [The Editors regret that they are unable to print this paper, which has been unfortunately lost.]

MEETING, February 20th, 1873.

The second meeting of the term was held in Mr. Grenfell's Room; there were forty-five members and twenty-seven visitors present.

Donations acknowledged:—Fossils presented by A. Cole-Hamilton, and Sea-weeds by C. Carrington.

J. Duncuft rose and proposed a vote of thanks to Mr. Grenfell for his paper on Super-saturated Saline Solutions, which had been omitted at the previous meeting from want of time. The motion was seconded by R. M. Johnston, and carried unanimously.

Mr. Stoddart read a paper on the "British Araneidæ." The subject was commenced with a brief sketch of the wonderful anatomy, and the well-marked characteristics that distinguished the Spiders from Insects. An account was afterwards given of their habits, their various modes of constructing webs, which are so peculiar to each genus as to be generally useful in naming them. Attention was particularly drawn to the figure of each web, and the functions of the different spinnerets, and the part which each takes in weaving the thread.

Mr. Stoddart concluded by describing the ways of collecting the several kinds of Spiders, and gave a short list of many rare species that he had found in the neighbourhood of Bristol and Clifton.

The paper was fully illustrated by drawings and diagrams.

A vote of thanks was afterwards passed to Mr. Stoddart for his interesting paper.

MEETING, March 6th, 1873.

The President in the Chair.

The third meeting for the term was held in the Chemistry Room. Forty members and fourteen visitors were present.

Donations acknowledged:—Fossils from G. Spencer Percival, Esq.; Fossil Coral—Lithostrotion Arenea—fine polished sections by Firth, ma.; Pinna from Carboniferous Limestone, Clifton, by the President.

The following new members were elected:—Wansbro-Jones, Glynn-Price, Browne, and Sherring.

The President explained the use of the weather charts, which are now placed in the Cloisters every morning.

R. M. Johnston next read a paper on some recent Inventions. The paper was illustrated with some very effective experiments.

THE NEW HYDROGEN GAS.

Although my paper this evening is chiefly on the "New Hydro-Carbon Gas," as a substitute for Coal Gas, yet my intention is to bring before your notice several improvements and inventions in other branches.

But, first, I shall proceed with the Hydro-Carbon Gas. Every one of you who has touched a newspaper within the last six months must have become heartily tired of the numerous articles written on the cost and scarcity of coal, besides many impossible proposals to find substitutes for it. And yet it is a subject of great importance, worthy of your deepest attention, and one that is occupying the minds of many of our leading men of science. What would England do if her coal-fields ceased to yield their valuable produce? Could you bear to see England drop from her seat among the greatest powers in the world into a purely agricultural Island of no importance? May that time be very far distant! We are told that at the present rate of consumption our coal supply will last for 200 years, so you or I are never likely to see the last of it, yet we should do well to have a means of making gas independently of coal. At present the high price and scarcity of coal is due to the miners being on strike rather than to its supply having actually failed. The present scarcity may not be thrown away if it will only teach people its real value, and make them less wasteful of this blessing.

There are several plans on foot for new gases to take the place of coal-gas, but the first I shall mention, and in my opinion the best, is called the Hydrogen or Hydro-Carbon Gas, patented by Mr. Ruck. I had always thought it an impossibility to set the Thames on fire, but I will endeavour to show you that Mr. Ruck has, by the new gas, literally succeeded in doing this. From Thames water he obtains hydrogen, which is the principal component of the gas, and therefore, he is really burning Thames water.

The gas is formed in the following manner:—Steam is led from a large boiler by a pipe into a horse-shoe tube, maintained at a red heat by being inserted in a coke furnace. By this means the steam is superheated, and raised to a temperature such that it breaks up into its constituents, namely:—Oxygen and Hydrogen. It is then passed into retorts at the lower part of the furnace, loosely packed with coke and old iron, generally in the form of old iron chain for the convenience of withdrawal. The gases have to traverse the entire length of the retorts amidst the heated metal. The Oxygen combines with the iron forming black iron rust, and the Hydrogen passes on with only a slight taint of Carbonic Acid, and a very small percentage of sulphurous vapours. The chemical change may thus briefly be expressed:

$$4\ H_2\ O + 3\ Fe = Fe_3\ O_4 + 4\ H_2$$

In this impure state it is passed into purifying chambers containing oxide of iron, and is at once rid of the sulphur compounds, and is then stored in an ordinary gasometer. In this state it is technically the "heating gas," that is to say, expressly suited for purposes where heat without light is required, as for gas stoves or for cooking. When this gas is taken from the reservoir and discharged through an ordinary gas jet it burns with a pale colourless flame, in fact it is the hydrogen flame. At the present time, with gas coals at 26/- a ton in London, the production of a "heating gas" at a small cost and with but a small consumption of coal, is a most important, a most valuable discovery. At the Battersea Works, where experiments are being made so as to give it a thorough trial, it is found that by the expenditure of one ton of coke for the interior of the retorts and two tons for the furnace, 133,000 cubic feet of gas are produced, which, to say the least of it, is equal to ordinary gas for heating purposes, and can be stored with perfect ease and transmitted unlimited distances through pipes. The heating power of this gas found, experimentally, to give the following results :—One quart of cold water was boiled in $4\frac{1}{2}$ minutes by a jet of gas issuing from a pipe $\frac{1}{8}$ inch in diameter, and under a pressure of 3 inches water. This was estimated to burn about 5 cubic feet per hour. Now the cost of this gas at the works was found to be 7d. for 1,000 cubic feet, so, in the above experiment, it was equivalent to converting 7 gallons of water from 38° Farenheit to 212° for 1d., and 1,000 cubic feet at 7d. would boil about 50 gallons of water. I will now proceed to the second part of the process, that is to say, to make it a luminous gas. To make this gas a highly luminous one, it is necessary to bubble the "heating gas" from the gasometer through rectified petroleum having a specific gravity of about ·68—it then passes directly through pipes to the burners as an excellent gas, having an illuminating power equal to about 21 candles.

I will now try and show you, with the apparatus I have got here, first the heating gas, then the illuminating gas, and afterwards a mixture of the latter with coal gas, so that you may judge for yourselves as to their comparative value

The cost of the illuminating gas is a little less than 1/8 per 1,000 cubic feet, and the saving in the manufacture over ordinary coal gas, with coals at 26/- per ton, is estimated at 40 per cent. when coal gas being at 2/4 per 1,000; but at some places it is already at 6/- per 1,000. One thousand feet requires $1\frac{1}{2}$ gallons of petroleum, by which it is considerably increased; 133,000 cubic feet of "heating gas" becomes 165,000 cubic feet of "illuminating gas"—an amount that could not be obtained from less than 16 tons of coal, besides about 50 to feed the furnaces. The Company have made arrangements to purchase several million tons of petroleum, at a cost of about 6d. per gallon. Some very severe experiments have been tried to test the power of the gas to retain its full charge of carbon through long ranges of pipes, at

a low temperature. The testing engineers report that there was no apparent loss of illuminating power. The furnace and retorts at Battersea are very compact, occupying the space of an ordinary engine of about 30-horse power. These retorts are only in use two hours out of the twenty-four, and it is estimated, if at work all day, they are quite large enough to supply a small town of 4,000 inhabitants. As regards the most important bearing of saving of manual labour, it is found to amount to dispensing with the services of 29 out of 30 of labourers required in the old coal distillation process.

AIR GAS.

The second new gas is called the "Air Gas;" it is patented by a Company called the Air Gas Light Company (Limited.)

Its preparation is even simpler than that of the former gas. It is made thus, on a small scale: Atmospheric air is forced through a bottle containing Hydro-Carbon Oils; the patentee's secret consisting in the proper mixture of these. In fact, it appears that it is the vapour of this mixture that burns, the air being used only as a means of carrying the vapour. The great advantage it has is that it can be made in the house, and is very applicable for country houses, the apparatus being so simple and occupying so little space, that a servant of ordinary intelligence can work it easily. The apparatus costs £7 only, and is able to supply 25 burners. The inventor claims that 1,000 feet of his gas are equal to 2,000 feet of coal gas, and it can be produced at a cost of about 1/3 per 1,000 feet. It is, therefore, very much cheaper than coal gas.

In the "Hydro-Carbon Gas" a certain quantity of coal is necessary, although but little, while in the "Air Gas" none is used whatever.

NEW COAL GAS RETORTS.

I wish now to mention an improvement in the making of coal gas. In the process now in use the outside of the coal gets heated and burns before the centre of the coal does, so that a great deal of the available gas is wasted. A patent has been taken out for the following machine. An ordinary gas generating retort is taken, and fixed upright in the furnace; through it runs a long spiral screw, which is kept turning by some very simple machinery. It is a self-feeding machine, having to be supplied with small coals about twice a day. The screw keeps turning, and thus exposes the whole of the coals by turns to the heat of the furnace. The coal finds its way down by degrees to the other end, and having had all its gas extracted, falls into cold water. This process, it is found, extracts the gas much more thoroughly from the coal, and that a much greater quantity of gas is obtained by this than by the old process, and it is also of a better quality.

The advantages, then, appear to be—

First—That the gas is extracted thoroughly from the coal, and an increased quantity of gas of a superior quality is obtained.

Secondly—That as it works almost automatically, more than half of the manual labour can be dispensed with.

SAFETY LAMP.

The last thing I have to mention to-night is an improvement in the Davy Safety Lamp. But for the rashness of the miners in exposing the bare flame, the present Lamp would be sufficient to secure the miner from danger, under certain conditions. Only lately it has been proved experimentally, by Mr. Galloway, that a sound-wave is capable of driving the flame through the gauze; there is, therefore, an end of the Davy Lamp as a Safety Lamp. A sound-wave may be caused by the firing of a gun, or by blasting coal. The miners have themselves to thank for many of the explosions; they often open their Lamps, either to get a light for their pipes or to get a stronger light to work by. But although the plan of locking the Lamps has effectually prevented the former practice, yet the miner still obtains a light for his pipe by a simple but dangerous device. He tilts the Lamp till the flame plays on the gauze, or makes it red hot; and there cannot be much doubt that in some cases it has resulted in disaster. Notwithstanding the precautions taken for their safety, both by the government and their employers, no less than 400 miners lose their lives annually, and in almost every case through the carelessness of one of their number. The principle on which the Davy Safety Lamp is based is this:—A gas will not ignite until raised to certain temperature. So if an explosive gas is separated from a flame by wire gauze which conducts away the heat too fast to allow the gas to be raised to *that* temperature, it will not ignite. Davy, in his Safety Lamp, used a small oil lamp, and surrounded its flame by a cylinder of gauze about four inches in diameter, and having about 700 meshes to the square inch.

When fire damp, which is a compound of Carbon and Hydrogen, and which becomes a very explosive gas when mixed with about eight times its volume of air, comes in contact with the Lamp, it passes through the gauze and burns inside the Lamp, but cannot set fire to the gas outside because the wire gauze conducts away the heat too fast to allow ignition to take place. The only effect the slight explosion inside has, is to warn the miner to seek a place of greater safety. From what I have said before, it would appear that the Safety Lamp, in its present state, is not complete. The essential points for a Safety Lamp, then, may be stated in the following conditions:—It must be proof against over-heating by its own flame. It must give the maximum amount of light, and when trimmed it must be secure from all tampering; and also it must have a flame so well protected as not to be influenced by sudden currents or sound-waves. These conditions are tolerably well carried out in Mueseler's Lamp, in which the bottom portion of the gauze is replaced by a cylinder of stout glass, while a metal chimney over the flame creates a draught strong enough to keep the glass comparatively cool, and insures perfect combustion. This Lamp, however, is liable to accident through the breaking of the glass. Among the numerous designs that have recently appeared, probably the best is that patented by Mr. Yates.

Following the steps of previous inventors, he removes the ower portions of the gauze, and on one side replaces it by a "bull's eye," or strong lens, the other side being occupied by a silvered reflector. By this means a more brilliant light is obtained than would be possible with a naked flame ; so that the temptation to take off the protecting cover in order to see better, is entirely removed. At the same time the lighting of a pipe is rendered impossible, for the flame is placed so much beneath the gauze that it cannot be brought to bear on the sides, either by blowing the flame or tilting the Lamp; and any successful attempt to open the latter puts out the light before the flame can be exposed. The oil reservoir also contains a small sponge, which soaks up sufficient oil for use, and all the superfluous oil is poured out before the Lamp is given to the miner, so it is not liable to get easily out of order. A screw governs the locking-bolt, which can be easily drawn back and the lamp opened; but this operation cannot be done without also putting out the light. There is one "defect" that draws attention at once, and that is, it is more expensive than the others; but the inventor states that the saving in one year's consumption of oil will cover the extra outlay. This new Lamp, like Mueseler's and most others of similar construction, is put out when the air becomes highly explosive—and under certain circumstances this might be considered a disadvantage—but for general use in mines it seems best that it should go out when the air is highly explosive. Mr. Yates cannot do better than submit his invention to Mr. Galloway's tests against the wave theory; for if it is proof against the "wave of compression," it will undoubtedly be a great advance in the safe working of mines. It may be urged that, let a Lamp be ever so safe, there is no security against the surreptitious use of matches by the miners, except by the expensive means of thorough ventilation ; but it must be conceded that, while it is impossible to detect every miner who may have lucifers concealed upon him, it is equally impossible to thoroughly ventilate some of the fiery collieries of this country without employing an air-current scarcely less gentle than a whirlwind. However, let us hope that Mr. Yates' invention may be successful in lessening the immense loss of life in our collieries.

Time does not allow of my entering more fully into these or many other of the most interesting inventions that are daily being made ; but I hope my imperfect paper on this subject may inspire some of you with a wish to investigate these things much more exactly than I have been able to do.

The President, Duncuft, and Allen, spoke on the paper.

The President proposed, and J. Duncuft seconded, a vote of thanks to Johnston for his paper, which was carried unanimously.

MEETING, March 20th, 1873.

The President in the Chair.

The fourth meeting of the term was held in the Chemistry Room. Seventy members and visitors were present.

At the proposal of the Rev. J. Greene, it was passed that "a vote of thanks be sent to Mr. Barton for the trouble he has taken in arranging the Coleoptera in our Museum."

G. H. Wollaston, Esq., the new Science Master, and J. A. Gibbons, were elected Honorary Members, and J. Whidborne, Esq., a Corresponding Member.

Mr. Wollaston, in a few words, thanked the Society for the hearty way in which he had been received, and said he should always do his utmost to support the Society.

W. A. Tilden, Dr. Sc., then proceeded to lecture on "Some Chemical Experiments of the last Century," dwelling specially on the discoveries of Charles William Schule, a Synopsis of whose discoveries had been distributed to the audience.

The lecture was illustrated by many successful experiments, which were received with much applause.

A vote of thanks to Dr. Tilden was unanimously passed.

MEETING, April 4th, 1873.

The President in the Chair.

The fifth meeting of the term was held in the Chemistry Room. There were 67 members and visitors present.

The President announced 3 casts of Fossils (Euphrynus Prestwichii and Encrihusus cristagalli) from Mr. Woodward, of the British Museum.

J. Duncuft then read a paper on "Snake Bites."

R. M. Johnston then read a short paper on "Gas Lighting by Electricity," a continuation of his paper of March 6th.

The office bearers for next term were now elected. R. M. Johnston, proposed by Duncuft, was elected Treasurer.

For the Committee :—

G. Dakyns,	proposed by	Wills,	seconded by	Johnston,	received	21	votes
G. H. Wollason	„	Dakyns	„	George	„	38	„
C. L. Ivens	„	Bean	„	Moser	„	35	„
J. Allen	„	Duncroft	„	Stone	„	35	„
A. Darley	„	Johnston	„	F. Jones	„	28	„
J. Bean	„	Fell	„	Wills	„	26	„

Messrs. Wollaston, Ivens, Allen, Darley, Bean, were therefore elected.

MEETING, April 12th, 1873.

The President in the Chair.

An extraordinary meeting was held in Mr. Grenfell's Room.

The Treasurer, J. Allen, read the accounts for that term, showing a balance of 13s. 3½d.

H. Wills then proposed, and Jenkins seconded, the motion that "there be an extra number of committee for *next term*." This motion was carried.

H. Wills then proposed that G. Dakyns be the extra member, was seconded by R. M. Johnston, and carried.

J. Duncuft then proposed that "this Society apologise to G. Dakyns for the apparent want of confidence placed in him, and that he will return to the post he has so ably filled." This motion, after some discussion, was carried.

This was the last meeting of the term.

SECOND TERM, 1873.

MEETING, May 13th, 1873.

The President in the Chair.

The first meeting of the term was held in the Physical Lecture Room. There were Thirty members and visitors present.

The President proposed, and G. Dakyns seconded the motion, that a new office be instituted under the name of Vice-President, and that G. H. Wollaston, Esq., fill that office. Both these motions were carried. H. S. Hall, Esq., was elected an Honorary Member.

The following members were elected by the Committee:—A. C. St. Paul, A.W. Armitage, J. P. Marsh, G. Fitz-Gibbon, R. Fitz-Gibbon, T. H. Bailey, Berthon Heath, and M. Wills. From the Junior School—Reynolds, Thurburn, Hathaway, and Somerville.

Donations acknowledged:—Two Books, The British Paleozoic Rocks and Fossils, by Sedgwick and McCoy, and the Catalogue of Cambrian and Silurian Fossils, presented by Rev. H. J. Wiseman; Skulls of two wolves by Firth; Fossils by the President; Coins (Jamaica) and Fossils by Capt. Jones; Egyptian Necklace, with a figure of Pæhl in porcelain (dug out of an Egyptian tomb in 1840), from R. M. Johnston.

H. C. Jones then read a paper on "Sugar," after which the Secretary read a paper by G. Locke (O.C.), on "Diamonds."

The President spoke at some length upon this paper, and stated that the printed lists of the Society would be ready on Saturday.

For the directorship of the sections the following were elected:—

The Archæological Section	. .	C. L. Ivens
Botanical „	. .	G. H. Wollaston, Esq.
Geological „	. .	J. G. Grenfell, Esq.
Chemistry & Physics „	. .	R. M. Johnston
Zoological „	. .	G. Dakyns.

MEETING, May 29th, 1873.

The President in the Chair.

The second meeting of the term was held in the Chemistry Lecture Room. Twenty members were present.

The President acknowledged the following donations:—Prawn caught at Madras by P. Duncan, O.C., Assistant Engineer, P.W.D., Allahabad.

So few members being present it was determined to postpone the reading of Ivens' paper.

The President stated that the Head Master had given his sanction to the Society's proposed excursion. Some discussion took place as to where the Society should go.

MEETING, June 5th, 1873.

The President in the Chair.

The third meeting of the term was held in the Chemistry Room. There were Forty members and visitors present.

Donations acknowledged: Brachiopoda from J. G. Grenfell, Esq.

C. L. Ivens then read a paper on

HEREFORD CATHEDRAL.

The subject of this paper requires, I think, some apology. I have perhaps gone out of my way to describe a Cathedral Church at some distance from us, in preference to any of the many interesting archæological remains in our immediate neighbourhood. My aim, however, was, by describing as far as possible some of the more striking points, to induce any members of this Society, when they have the time, to visit one of the most venerable remains of antiquity in the West of England.

The Bishoprick of Hereford is one of the oldest in England. We hear of a Bishop of Hereford as early as the middle of the sixth century. It was probably about this time that the first church was built here, principally, it would appear, of wood. In connection with

its early history, the most important event is the murder of Ethelbert, king of East Anglia, at the instigation of Quendreda, the wife of Offa, king of Mercia, whose palace was at Hereford, or Fernley, as it was then called. According to William of Malmesbury, Ethelbert, was attacked by two assassins whilst praying in the chapel of the king's palace. The body, which was accredited with the performance of certain miraculous cures, was interred within the Lady Chapel, and a shrine was erected before it. There was, until recently, preserved at the Deanery a very curious Pyx, which formerly stood on the high altar of the Cathedral, and on the exterior of which was supposed to be depicted the murder and funeral of Ethelbert. It was formed of oak, and overlaid with plates of copper. Inside was a piece of wood stained with a dark liquid, supposed to be the blood of St. Ethelbert, for he was canonized shortly after his death. It is probable that the possession of the body of this saint contributed as much to the prosperity of the church as that of St.Thomas à Becket did to Canterbury. At all events in 825 a stone church was erected on the site of the former one. This having fallen into decay a larger edifice was commenced in 1030 by Bishop Athelstan, which may be considered as the original church from which the present one has sprung, although, of course, greatly enlarged. In the year 1055 the city of Hereford fell into the hands of the Welsh, and the greater part of the new church was burnt down. Indeed it was for a long time a disputed point whether any part of the present Cathedral, beyond the ground plan, was to be ascribed to Athelstan. It is, however, now generally admitted that a considerable portion of the south transept, the south aisle of the choir, and the vaulted entrance of the present chapter house, are his work. In 1079 the present choir, with its fine Norman arches, was built by Robert de Loying. It has an unusually gloomy and solemn appearance, occasioned partly by the heavy Norman architecture, and partly from the lofty transepts, which prevent the admission of light except from the clerestory. It is said to have been planned on the model of the Cathedral of Aix-la-Chapelle, erected by Charlemagne. Praynelm, the successor of Loying, built the nave, the arches of which are also adorned in the Norman style. The old west front, now destroyed, was due to the same hand. Lastly, the great central tower was erected in 1200. The ball-flower ornament with which it is now so profusely studded, must have been added at least 150 years later. This tower was originally surmounted by a spire.

Such, then, is a brief sketch of the old Norman church. The profuse and elaborate ornamentation of her later periods, make it very difficult for us to realize the massive simplicity of the original design, but it probably bore no inconsiderable resemblance to our own Cathedral here in Bristol, if, as Mr. Street conjectures, there existed an old Norman nave before Abbot Knowle built the present choir.

But at the time of which we are speaking, the beginning of the 13th century, a complete revolution was being effected in architecture. The old Norman or Romanesque round arch began to fall into disuse,

and gave way to the pointed arch of the early English time. One of the most beautiful specimens of this style is the Lady Chapel of Hereford, which was built between the years 1230 and 1250. It consists of three bays, having in each two lancet windows with richly clustered shafts, at the intersection of which are small heads and capitals of early English leafage. It was erected, according to the usual practice, at the east end of the choir. Some 40 or 50 years after its completion, a further extension of the church, changing the shape of the ground plan from a single to a double cross, was effected by the building of the eastern transepts north and south. At the same time the present clerestory and stone vaulting were added to the Norman choir, and the aisles were rebuilt. About the middle of the 14th century the north transept was enlarged to hold the remains of St. Thomas of Cantilupe, one of the most celebrated Bishops of Hereford. Following the custom of the time, he was no less distinguished as a lawyer than as an ecclesiastic, and became Lord Chancellor of England to Henry III. The name of his old London residence, Cantilowe's Town as it was called, still exists in the corrupted form of Kentish Town. He died in Italy, in 1282, on his return from Rome, whither he had gone to obtain redress for encroachments made on the rights of his church by the Archbishop of Canterbury. His bones were brought to his own Cathedral, being first deposited in the Lady Chapel, and transferred to the transept on its completion in 1286. The shrine, when first erected and for many years after, was visited by pilgrims and travellers from all parts of Europe. Matthew, of Paris, assures us that soon after the arrival of the remains, no fewer than 163 miracles were performed here. This Bishop was the last Englishman who was canonized.

The most interesting point in connection with the Cantilupe aisle, as it is called, is, that over the pointed windows on the east and north sides are found circular windows in round arched niches. It is not often that the circular arches are to be found, as in this case, over the pointed ones. The only other instance of it that I know of is to be found at Llanthony Abbey, in the north of Monmouthshire.

It was at this time that the central tower received the decorated work with which it is so profusely covered. A west tower was also erected about the same time. Thus, with the Cantilupe aisle, the work on the central tower and the smaller transepts are all in the decorated style which then began to prevail.

The next addition to the Cathedral Church, made between 1453 and 1474, is Bishop Stanbery's chantry on the north side of the choir, which is a very good example of the late perpendicular. The vaulting is richly groined, and at the angles of the chapel are some very grotesque capitals. A little later were built the Audry Chapel, the north porch, and the cloisters.

This was the form of the Cathedral, and thus it remained, seemingly, without any attempts being made to keep it in preservation, until,

on the evening of Easter Monday, 1786, the masonry at the north-west angle of the west tower gave way, and, in consequence, the tower itself came down, involving the whole of the west front in destruction. This misfortune could not have happened at a more unfavourable time, owing to the low ebb to which architectural taste had fallen. £13,000 were expended on the restoration, and the architect is said to have declared it to have been the cheapest piece of work he had ever done. As an instance of the manner in which it was carried out, I may mention that no attempt was made to lengthen out the nave to its original proportions, so that as the western arches were totally crushed by the fall of the tower, the original length of the church has been reduced 15ft., the span of the eighth arch. This disproportionate shortness of the nave still constitutes a grave defect in the appearance of the church.

However, a second and more efficient restoration was commenced in 1858, under the superintendence of Sir Gilbert Scott, the result of which has been the complete renovation of Bishop Booth's porch, the north and south-east transepts, the Lady Chapel, the cloisters, Audry Chapel, and other parts of the building, which had all been in more or less advanced stages of decay.

Among the points in the architectural features of this Cathedral Church most worthy of notice, the north porch is one of the most interesting, having been built by Bishop Booth, in 1530, in the rich late perpendicular style, at a time when it had been superseded by the debased style in most parts of England. It is constructed of four clusters of pillars supporting as many pointed arches ; these pillars are 6ft. in height, and rise 12ft. from the level of the capitals to the crown of the arch. It is fitted on to the more ancient porch of the Cathedral, which is of a simpler description. The choir is separated from the nave and transepts by a metallic rod screen, which has been considered the finest and largest piece of architectural metal work ever executed. It consists of five arches, each subdivided by a slender shaft ; of these the central one forms the entrance, those on either side are filled in with panels of tracery to a height of 4ft., while the heads of the arches and the spandrils between them are enriched by elaborate tracery, consisting mainly of flowers and leafage. The height of this screen is 16ft., the breadth 36ft. The shafts of the smaller columns are made of brass : the capitals, figures, and cornice, of iron. The iron work forming the foliage, as well as some of the brass work, is painted; but no colours have been employed excepting the oxydes of the metals used : the copper is left throughout its natural colour.

In the south aisle of the choir there is preserved a curious map of the world, drawn on thick vellum, and believed to be the most ancient one in existence. It is most probably as old as the 13th century, and is the work of a monk belonging to the Cathedral Church, and Archdeacon of Hereford. On the left side Augustus Cæsar is represented as sending forth three philosophers, named Zichodoxus, Theodotus,

and Poligelitus, to survey the three divisions of the world when it was about to be taxed. The Emperor is represented as delivering to them written orders confirmed by a mediæval seal. In the apex is represented the day of judgment, with the Virgin Mary interceding for the faithful, who are rising from the graves and entering heaven. The world is represented as a circular plane surrounded by the ocean; rather more than the upper half is allotted to Asia, the Mediterranean separating the two lower quarters, Europe and Africa. At the top is the Garden of Eden, with the eating of the forbidden fruit, and the expulsion of our first parents. Jerusalem is made the central point of the earth. The only other cities which are marked beyond Great Britain are Babylon, Troy, described as Troja civitas bellicosissima and Rome. Yet in the mediæval grotesqueness we have most of the Cathedrals marked in Great Britain; Hereford appearing as "Sancti Ethelberti Ecclesia." Many scriptural incidents are pourtrayed, mixed up with legends taken from Herodotus. There are also numerous figures of animals, many of which assigned to the various countries with an utter disregard for facts, monkeys, for instance, being represented in Norway, and scorpions on the banks of the Rhine. The fact that so many of the legends are taken from scriptural history, has given rise to the conjecture that it was intended for an altar piece of one of the chapels of the Cathedral. The map is elaborately drawn in colours on vellum, and shows that its author must have been a distinguished calligrapher. At present, however, age has made it almost impossible to decipher some parts of it.

The most conspicuous object in the north transept is a geometrical window of stained glass, said to be the largest of its style in the United Kingdom. It was erected in 1804 by the Freemasons of England, in memory of a former Archbishop of Hereford. The window contains six lancet lights in two triplets, divided by a central mullion into two designs: that on the western side representing the church militant, that on the east the church triumphant. In the base appear various masonic emblems: indeed, although imposing, it looks rather out of place in a Cathedral.

The tomb of Bishop d'Aquablanca, which is in this transept, is one of the finest of the many monuments of Hereford. The effigy lies under a rich and sharply pointed canopy, in three divisions, supported by slender shafts of Purbeck marble. The gables of the canopy are crowned with floriated crosses.

Of monumental brasses there are more remaining in Hereford than in any other Cathedral.

There is an interesting monument in the nave to Sir Richard Pembridge, who was created a knight of the garter by Edward III. for services on the field of Poictiers. It is said to be the earliest existing representation of a knight with the garter.

In connection with the Cathedral, the Bishop's palace is also deserving of notice. It was formerly a Norman hall. The size of this hall may be imagined from the fact that it is at present divided

into a drawing room, dining room, entrance hall, and the Bishop's private rooms. The roof is supported by two ranges of wooden pillars, with Norman capitals of wood.

At the end of the Bishop's cloisters is the site of the old Chapter house, which is said to have formed a most beautiful appendage to the church. It was a decagon 40 feet in diameter, supported by a central column, with a window on either side. Under each window in the interior were five niches, in each of which was painted a portrait as large as life. During the siege of Hereford by the Covenanters under the Earl of Severn, in 1645, Scudamore, the Royalist Governor, had the Chapter-house roof stripped of its lead covering to defend the roof of the tower in the castle. From that time it rapidly fell into decay, and at the present time nothing but the base remains. The approach to the Chapter-house was through a square turreted tower, which still remains, and goes by the name of the Lady Arbour. The origin of this title is uncertain. It has, however, been suggested that just as it was common in mediæval times to have an apartment in houses called the "Lady's Bower," so this was called the bower of our Lady, in honour of the Virgin Mary. Although, so far as I am aware, there is no similar instance of such a structure elsewhere, there is, in the Bristol Cathedral, at the south-east corner of the upper cloister, a curious pseudo-gothic arch, which Canon Norris, in his account of our Cathedral, conjectures to be remains of a "Lady's Chapel" like the one at Hereford.

In the library, which is situated over the Cantilupe aisle, there are about 2,000 volumes, of which between 200 and 300 are MSS. The oldest of these is an Anglo-Saxon copy of the four gospels, bequeathed by Athelstane, the last Saxon Bishop of this See. There is also a Bull of Innocent IV., promulgated in consequence of some of the clergy of the Church refusing to contribute towards the repairs. The library also formerly contained the celebrated Hereford missal, which has lately been transferred to the British Museum. It is one of the rarest and most valuable of old English documents which we possess. The history of its discovery is very curious. It was found in 1858 lying open on the floor in an old house in Bristol, among some hundreds of other books which had belonged to the English Franciscans, and which had been brought by them to England from their convent in Belgium, during the troubles of the first French revolution. It was printed in the year 1502, at the famous Rouen press.

The list of the clergy connected with this church is singularly barren of names of any permanent historical interest. Richard Swinfield, however, who was Bishop of Hereford 1289-1316, left a roll of his household expenses, which has come down to us and was printed a few years ago by the Camden Society. It is interesting as being the earliest extant picture of English domestic life. How this prelate lived will appear from the following list of articles provided for his dinner, Christmas Day, 1289: there were provided a boar, ten oxen, eight porkers, sixty fowl, thirteen fat deer, and 900 eggs.

In conclusion, I would say that although I have been unable to do more than describe a few of the principal points connected with this Church, there is much besides which would repay the closest study. For Hereford Cathedral is pre-eminently one in which it is not so much the general boldness of outline as the delicate workmanship of the various parts which constitutes the main charm.

C. L. I.

The Secretary, G. Dakyns, then read an extract from a newspaper, on some interesting experiments on the brain, which had been recommended to the attention of the Society by Rev. P. A. Phelps. The President supplemented the extract with some very interesting remarks on the subject.

MEETING, JUNE 26TH, 1873.

The PRESIDENT in the Chair.

The fourth meeting of the term was held in the Chemistry Room. There were Forty-three members and visitors present.

Donations acknowledged :—Fossil (Nautilus Subsulcatus), from the upper limestone shales, Clifton, presented by J. E. Jose, Esq.; Rugby School Natural History Society's Transactions for 1872 ; two Leopard Skulls, from India, and a pair of Eagle's Claws, from F. M. Reynolds ; Slab, from the lower limestone shales, from President.

G. H. Wollaston, Vice-President, then read a paper on

CERTAIN WEALDEN BEDS.

The title of my paper for this evening is most likely altogether unintelligible to most of you, so I shall preface it with a few words of explanation.

The Weald is the name given to the country lying in parts of Kent, Sussex, and Surrey, between the North and South Downs; a beautiful country, which has earned for itself the name of "the garden of England," and in which large stretches of bleak and open common, alternate with hop gardens and corn fields, and many large patches of woodland, testify to the fact that it was formerly a vast forest or weald, while the great number of village names enduring in hurst and den tell the same story. It was long a wooded country, and supplied a large quantity of oak to the English Navy, but the woods gradually disappeared in consequence of the demand for the iron works, which were at one time the most important in England. It is said that the oldest piece of cast iron in England is a tablet in Burwash Church, bearing the words: "Pray for the soule of Joan Collins." The railings round St. Paul's, in London, were cast at Lamberhurst.

The highest part of the Weald is at Crowborough, near Tunbridge Wells, where it reaches the height of 800ft., and from this point it

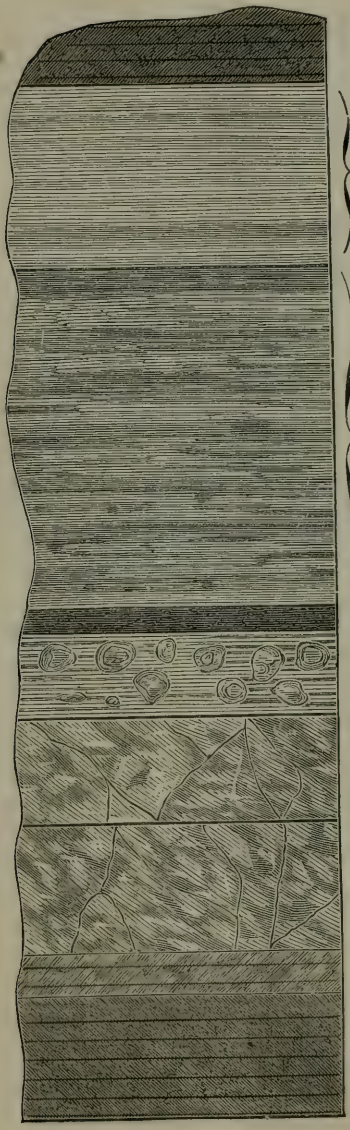
descends to the foot of the Downs in both directions, by a long series of undulations, while nearly all the streams which take their rise in it flow right through the chalk escarpment as though they had had channels dug for them. There is no doubt that the chalk formerly covered the whole of this area, and that the streams which then flowed across it, either northwards or southwards, held on their course, while in the course of ages the most elevated part of the chalk got carried off, and the lower beds which are now seen were exposed to view.

These are the Wealden Beds, of which I am to speak to-night—their history, too, is interesting.

At the close of the oolitic period, before the waters of the deep ocean, in which the chalk was deposited, covered our part of the world, a large river, probably coming from the north-west, flowed into the sea and left a delta, the remains of which we now see in Dorsetshire, Kent, Sussex, and on the opposite coast of France. At one time it brought down sand, at another mud. Plants grew thickly on its banks, and by their decay formed peat, now converted into coal. Gigantic lizards browsed on the vegetation, while crocodiles fed on hard-scaled fish in its waters; and its lagoons, alternately fresh or salt according as the sea or river got the mastery, gave shelter to multitudinous oysters or fresh-water mussels. Of all these changes the rocks are witnesses.

One of the main divisions of the Wealden Beds is the Ashdown Sand, a rock which is, however, not always sandy, but contains in places thick beds of limestone. This is the only available stone for building and for making roads in many places, and is therefore valuable. To obtain it the upper soil and clay are removed, the stone is quarried, the clay is put back again into its place, and a fresh part laid bare. Field after field is in this way worked through, and thoroughly turned over to a depth of from twelve to twenty feet. A new pit had been opened last summer near Hastings, and on entering it, I at once observed a band of hard stone a short way above the limestone, but unlike it, composed of pebbles. Pebble-beds are very uncommon in the Weald; when they occur they are found to consist of quartz, and the pebbles are usually small: the largest I ever found weighs just under four ounces. They are usually very much rounded, but in one case I found a crystal of which some of the faces were clearly visible. On breaking a fragment of this pebble-bed, I found it to be so firmly cemented that many of the quartz-pebbles broke right through, and that beside these there were many pieces of bone also, more or less rolled. On further examination I found numerous bones, teeth, and scales, and the quarryman told me that there was any quantity to be had. So I bought the whole bed of the man, at the same price as that which they got for the limestone below, and wrote at once to Professor Sedgwick, who, with his unfailing courtesy, sent, in a day or two, Mr. William Keeping, curator of the Woodwardian Museum, to help me to collect. For several days we

worked away, not only at this bed, but at the rocks above and below it; and some of the best bones we got from the clay, a few inches above the pebbles. It was a treat to see Keeping get the bones and teeth out of the hard stuff—you would think all was going to smithereens when out would come a perfect vertebra, processes and all; or if part of a long bone did jump out first he would still go on, and pick up the bit afterwards, in a trice, out of a heap of rubbish in which it seemed hopeless to search. It was hot work too, and we had several loads wheeled under an oak, which luckily stood in the field; these soon disappeared, and more were brought; so in time we got through many cubic yards of stuff.


Vegetable Mould and Soil—1ft.
Clay—3ft.
Shale and Sandy Clay, with here and there a little Vegetable Matter.
Entomostraca, Cyrena, Fish Scales, and Bones—6ft.
Bone Bed—2in. to 6in.
Clay with Iron and Limestone Concretions—1ft. 6in.
Limestone, passing laterally into Sandstone, Cypris, Cyrena, Paludina—4ft.
Sandstone, in places a heap of Cyrena, Scales, and Teeth—7in. or 8in.
Blue Clay.

SCALE, 3FT. TO 1IN.

It is difficult to say whereabouts exactly in the Section the real Ashdown Sand begins. I am inclined to think that the first four feet belong to the Wadhurst clay, but it is quite impossible to draw a line at any horizon in such rocks as these, no two sections even when very near each other giving the same results.

Mr. Keeping has kindly sent me the following list of the fossils which he found :—

Numerous vertebræ of Iguanodon, Citiosaurus, and Megalosaurus; teeth of Iguanodon and Megalosaurus; Phalanges, and coracoid of Iguanodon; teeth and vertebræ of Plesiosaurus; teeth, vertebræ, (?) femur scales, and various bones, not yet identified, of Gomopholis; dermal plates, scapula, and other bones of a Chelonian; tooth of an unknown Deinosaurian; spines of Hybodus; teeth and scales of Lepidotus; Coprolite; Unio, Cyclas, Paludina, Cypris, Estheria.

To these must be added the prints and remains of (?) Chara, Equisetum, and many ferns: one of the latter—a new species—was found by my cousin, H. U. Wollaston, in the sandy shales above the bone-bed.

The greater part of the fossils we collected are now in the Woodwardian Museum, but I have brought a few, which I have collected since, with me to-night. You will see how beautifully preserved the fish and crocodile scales are; and, by the size of some of the teeth, you will be able to form some idea of the dimensions of the monsters who bore them.

These beds are interesting as an evidence that at former periods of the history of the earth, just the same operations were going on as we see around us now. At the mouth of the Ganges we know that a series of beds very similar to these is being formed—layers of sand, mud, and clay are deposited, containing bones of fishes, crocodiles, lions, &c., and also of human beings. When we trace back the history of the world, long before the Wealden epoch, we find the coal measures, which were also formed in a delta. The face of the world is continually changing; races of animals and plants give place to each other; but just as sun, moon, and stars hold on their courses in the way appointed for them in the beginning, so also do the same great forces and the same great laws work on our earth, impelled by the same great worker, as they have in all the past ages through which we can half-blindly grope our way.

I hope that the account which I have given to you this evening, of our exploration of these beds, may encourage some of you in similar work. It does not require any vast amount of geological knowledge, it only requires a little patience and perseverance for any of you to form a collection of the fossils in any bed or series of beds in your neighbourhood: you will by this means get an insight into many interesting things of which you can have little idea, and will add to your knowledge of natural history in a way which is, I think, unsurpassed.

W. J. Bean afterwards read a paper on "Locomotives," illustrated by various diagrams.

MEETING, July 10th, 1873.

The President in the Chair.

The fifth meeting of the term was held in the Chemistry Lecture Room. There were Thirty-nine members and visitors present.

The following donations were acknowledged:—Fossils and Minerals (Celestine: and spiral Shells from the lower limestone shales), presented by J. G. Grenfell, Esq.; a Heron, by J. Saunders, Esq.; a Photograph of the Map of the World, in Hereford Cathedral, by Beddoe.

H. Wills read a paper on "Vases." The paper was illustrated by numerous engravings, and also by two ancient Greek vases, lent to Wills by H. R. Brown, Esq. The President spoke at some length on the paper.

J. Allen then read a paper on

ANTS.

I intend, in this short paper, to bring before your notice some of the works undertaken by these insects, and also to show, so far as I am able, their habits; and, finally, to enter into a description of these minute creatures.

The chief work perhaps of an ant is the construction of its habitation. Some may have seen the conical mounds, composed of straw, pieces of wood, stones, and leaves, that make up the nest of the large red ant (*Formica rufa*). But did you know that that mound was not a solid mass of matter, but was most admirably constructed inside to suit the convenience of its occupants: in fact it is so composed that the air and rain have no effect upon it, and heat and cold are alike regulated as is suitable. Viewing the mound exteriorly, you will find it is of a circular dome-like shape; the base being circular, and above it the wooden portion of the building rises in the shape of a sugar loaf. Now let us take a look at the interior. It is at once noticeable that there are a number of stories in the nest, one resting on the other. Some stories are above the earth, others arrayed some depth in the earth. In the summer, when the weather is very hot, the ants take their young ones to the lower stories, which are cool; and in winter, when the subterranean portion becomes damp, they go up above.

The nest of the brown ant (*Formica Brunnea*), contains often twenty stories above the earth, and twenty below. Each story consists of saloon-shaped cavities, narrower apartments, and connecting galleries. The arched ceilings of the apartments are smooth and firm, supported by columns, slender walls, or regular buttresses. Many chambers have only one entrance from above, whilst others have two, one from above and one from below. The galleries meet in one large apartment, which communicates with the subterranean passages, which again communicates with the exterior through long passages in the earth. The way in which these ants construct

their habitation was well pointed out by the Swiss Entomologist, M. Huber. He carefully observed them, and found that they work after sunset when the dew has fallen. He also noticed that after a storm they were very busy with the moist clay and earth. He observed some in a shower bringing little pellets of earth from the subterranean passages, and depositing them on the roof of the nest. After watching for some time he distinctly traced the little walls, columns, and passages of a new story. He noticed very carefully the way in which these insects fix the earth. The pellet of earth is obtained from the bottom of the nest by scraping with the mandibles; the ant then carries it in its jaws. After applying it to the required spot they divide it, and press against it with their jaws, so as to fill up all spaces, they then press slightly on it with their fore foot. The antennæ follow all their movements, repeatedly pressing over the pellet.

The operation of building a new story is reported to be exceedingly interesting to look at. The ants having traced out the plan of their structure, add new portions, and thus form walls: these walls they cover over by a vaulted ceiling. So quick are they in their work, that they will often erect a new story in seven or eight hours. If they have not finished a story while the rain is falling, or the earth is damp, and if they find they have no more moist earth, they destroy the portion of the new story which is unfinished and scatter the remains. It used to be thought that ants used some sort of glue to prepare the earth for their buildings, but M. Huber's experiments have settled this matter. He moistened a nest with fine sprinklings of water, and found that the insects immediately began to bring pellets from the bottom of their nest, and in a few hours had constructed a new story. But I have been talking only of the stories which they add to their habitations, but if we examine the subterranean portions of their nests, we find that the earth they dig to form a story, is scooped out in such a manner as to leave apartments below, even larger than those they form above. They therefore are constructing two saloons at once, one below the earth by mining, and another above, constructed from the earth which they dig out in their mining operations.

Another kind of ant, and one found in England, is the dark ash-colored ant (*Formica Fusca*). Their nest is simple and heavy in its construction, when compared with that of the brown ant. The mode in which they heighten their habitation is, however, very interesting. They begin by covering the roof with a thick layer of earth, which they bring from the interior. In this they trace out the plan of a new story, by hollowing out cavities of equal depth, and at different distances, and of a size adapted to their requirements. Thus they have the foundations for their new walls, and having built these to the necessary height, they cover over the apartments with a ceiling. M. Huber describes the work of a single ant. One rainy day he noticed a labourer digging the ground near the aperture which gave

entrance to the ant hill. Having placed in a heap the fragments it had scraped up, it formed them into pellets, and placed them on the nest. Soon he noticed a slight furrow excavated in the ground, representing the plan of a gallery. The labourer gave it greater depth and breadth, and it became evident that it intended establishing an avenue, which was to lead from one of the stories to the underground chambers. This was only half of the work of this single ant, for it furrowed out another gallery, parallel to the first, to another opening, leaving between the two a little wall three or four lines in height. It often happens that the ants who lay down the foundations of a story, owing to their working separately, occasion a want of coincidence in the parts, but they are by no means embarrassed by this. As an instance, a workman had constructed a wall, which was to support a vaulted ceiling, still unfinished, that had been projected for the wall of the opposite chamber. The ceiling, however, had not been elevated sufficiently, and if continued would have met the wall half way down, and this it was necessary to avoid. An ant, however, arriving and noticing the difficulty, immediately proceeded to pull down the ceiling and raise the wall upon which it rested; it then constructed a new ceiling with the fragments of the old one. And what are the tools and materials used in constructing these stories? The materials are earth, straw, and pieces of wood, which they may come across. If they find a straw or piece of wood arrayed so as to assist them in their work, they do not remove it, but make use of it. By means of the water they moisten the earth and make it adhere, and by the sun it is hardened and dried. Their only tools are their jaws and their fore feet, whilst they use their antenna to feel if everything is in its right position.

And now to pass on to some of those ants that form their nests in the trunks of old trees. The chief of these is the fuliginous ant (*Formica Fuliginosa*). This ant hollows out trees into numberless stories, more or less horizontal, the ceilings and floors of which are about five or six lines asunder, as thin as a card within, supported by vertical partitions, which form numerous chambers, or by a series of small slender columns, which leave a perfect communication through the whole story. The wood in which these ants excavate is always black, but the reason for this has not yet been explained. The red ant (*Myrimca Rulia*) also forms its lodging in trees, but not to such an extent as the fuliginous ant. The wood in the case of the red ant is not blackened; but the remarkable thing in the red ant is, that they not only lodge in trees, but often make their nests in the earth. The Ethiopian ant (*F. Œthiops*), and the yellow ant (*F. Flava*), can also lodge in the earth as well as in trees. The Ethiopian ant hollows out extensive lodges in the oldest trees, and makes use of the material it has scraped off, to fill up chinks, and to make compartments in those galleries which are too large. The yellow ant, when it takes up its abode in a hollow tree, constructs entire stories out of decayed wood. The decayed wood is mixed with earth and spiders' webs, and

thus possesses a consistency which enables the ant to use it in the formation of its story. Some ants will construct their nests in the leaves of trees. Sir Joseph Banks noticed, in New South Wales, a nest which consisted of two large leaves, held together by thousands of ants, and when these ants were driven away the leaves sprang back with great violence.

And now, having noticed the habitations of these insects, let us go on to consider some of their habits. You probably are aware that ants live in societies, and that there exist in these societies males, females, and what are termed workers. Of course, besides these, there are the pupæ and larvæ.

The females, when first born, have wings, but these they soon lose; their office is merely to furnish a constant supply of eggs, to keep up the number in its nest. The males also have wings; their only office is the impregnation of the females, and after this season has passed they die. By far the largest portion of the community consists of the so called workers, or sterile females. The workers in some societies are of two sizes. The large ones, which are found to be what are termed soldiers, are about twice the size of the other workers, and are armed with tremendous jaws, and their office is expressly to defend the rest of the community. M. Lund describes the movements of the soldiers during a march. He says that they do not mix with the mass of the moving column, but, stationed on their flanks, they are seen to march forward, then to return and halt a moment, as if to observe the troop defile before them, traversing its ranks, and hastening to any point where their presence is required. Sometimes they have even been noticed to climb up any plants that may be near, and watch the main body march past.

These, then, are the individuals making up a society of ants; we will now trace the life history of these individuals.

On looking into an ant's nest one can observe the pupæ heaped up in their lodges, and the larvæ collected together and guarded by the workers. Again one notices a number of workers following ants of larger size, these are the mothers, and as they walk along they lay their eggs, which are immediately taken up by the workers, who are following, in their mouths, and collected in little heaps. These eggs are of different forms and sizes. The smallest are white and cylindrical; the largest, transparent and slightly arched at each end; the medium size are semi-transparent. At the end of fifteen days the little worm, or larva, is seen to quit the shell. Its body is then transparent, and has a head and wings; is wholly unable to support itself, and therefore requires the assistance of the workers. The greatest possible care is taken of these larvæ. They are usually guarded by a number of ants, who are always prepared to attack an intruder. M. Huber noticed the ants conveying their young to enjoy the warmth of the sun. He saw the ants, as soon as the sun began to shine, descending rapidly to the bottom of the ant hill, and strike with their antenna the other ants, and jostle their companions, who

immediately hastened to the top, and then as soon came down to inform the rest. So violent were they in their movements, that some were observed to seize hold of those that did not understand, and drag them forth. After leaving them about a quarter of an hour in the sun, they placed them in shelter, and immediately proceeded to enjoy themselves. The larvæ obtain their food from the workers who attend them, by sucking their bodies, and searching, with their mouths those of their attendants who then open their mandibles, and allow them to take the juices they require. The larvæ are kept remarkably clean by the workers, who continually pass their tongues and mandibles over their bodies.

The next stage is that of the pupa, and a remarkable fact is, that there are some which become pupæ by forming a cocoon, and some that become pupa without spinning. The pupæ has the same shape as the adult insect, and all that is wanting seems to be strength. Those pupæ that are enclosed in cocoons are liberated by their attendants. The ants when first born are very helpless, and for the first few days are accompanied by the labourers.

We have traced the development of the eggs into males, females, and workers, now let us follow their existence in their various states. The males and females, as I said before, have wings. Now after they have assumed the adult form, between July and September, they quit the nest in which they were born, to seek a new home. Their departure causes a great excitement among the workers who have been attending them. The departure commences by the males, who, as from one given impulse, take their flight, and are followed by the females. The swarm takes no particular direction, but the ants raise and lower themselves alternately, about ten feet above the surface of the ground they have left. If a traveller happens to pass beneath the swarm, they follow and accompany all his movements. In all probability none ever return to the nest they have left. The question then naturally arises, what then becomes of these males and females who have thus taken their flight? The males no doubt die within a very short time, but the females, what happens to them? M. Huber has set this question to rest. He has discovered that the females, as soon as they light upon the earth, immediately, of their own accord, begin to divest themselves of their wings. Having lost their wings, they become industrious, and construct lodges, and lay their eggs. The eggs, larvæ, and pupæ are taken great care of by the mothers, until they finally assume the adult state, viz: males, workers, and females. It must not be supposed that all the females quit the nest; some remain, whose duty it is to keep up the population of the nest. Those females that are impregnated before leaving the nest are forcibly retained by the workers, who, just before the swarm take their flight, carry them off to the subterranean portion of the nest, and make them prisoners. The captive female is attended and guarded by a worker, who follows her everywhere, ministering to her wants: these are the females I spoke of before, who lay eggs in the nest which the workers carry away and store up.

And now for some interesting facts with regard to ants. First, regard them in their nest, and see how wonderfully they are related to each other. If, for instance, you excite the surface of a nest, the alarm will spread almost instantaneously throughout the whole community. Another interesting experiment, performed by M. Huber, is to place the legs of an artificial ant's nest in water. The little creatures will crawl down and lap the water. If, however, they are interrupted whilst in the midst of the enjoyment, the following scene may be noticed: most of the ants, in fright, return to the nest, but some, more thirsty than the rest, will continue lapping. If so, one of those who retreated will return to inform them of their danger; one he will push with his jaw, another he will strike on the breast; but if one does not heed these kind warnings, his adviser leaves off his tenderness, and seizing him by the leg, drags him away from the water. The loiterer, however, turns round in anger, with threatening jaws, and then coolly proceeds to drink again. The other ant, not to be daunted, rushes upon him, seizes him by the jaws, and carries him off to the nest. It has been thought by some that ants are enabled to regain their nests by following the route they took from their nest, by means of the sense of smell; but though this may assist them somewhat in returning to their nest, it is not by any means the only one they have. If an ant's nest is scattered in a room, the insects will diverge in all directions, and if one of them discover a place where they can secret themselves, it will return to its companions, and, by means of its antennæ, inform them of it. These in their turn act as guides to others who may be wandering about. Dr. Franklin discovered some ants regaling themselves with some treacle, he immediately put them to flight, and suspended the pot of treacle by a string. One ant had however been left, and this one climbing the string, crossed the ceiling, regained its nest, and conducted its companions to the treacle again. When ants are obliged to found a new nest owing to the destruction of the old one, the workers act as porters, and carry over the inhabitants to the new colony. The worker will approach the ant it wishes to convey, and caresses it with its antennæ, when the other is disposed to set off, he rolls up, is seized by the mandibles of the worker, and marched off in the most amicable manner.

Now let us see some of the wars that ants engage in. Those which are found in Europe will attack insects as large as the caterpillar and beetle, but those of southern countries will even destroy rats. They make their attack openly, their weapons being their mandibles and a sting which contains venom. If their adversary is at a little distance they raise themselves on their legs, and spurt the poison from their abdomen. The enemies which are most dreaded are ants themselves. A number of small ants will fix on a large one, and nothing will induce them to let go. If a large ant attacks a small, she does it by suprise, so as to prevent the small one seizing hold of her legs. They seize hold of the smaller ones by the upper part of the body, and strangle

them with their pincers. M. Huber witnessed a fight between the inhabitants of two large ant hills. Both armies met half way between their respective habitations, and there the battle commenced. Thousands of ants took their station upon the highest ground and fought in pairs. A considerable number were engaged in the attack, and in leading away prisoners. The fight usually commenced between two ants, who seized each other by the mandibles. After fighting for some time in the dust, they raise themselves, and each begins dragging its opponent: if equally matched, others come to their assistance, and so on. At night they returned to their nests, but began again at dawn.

The same observer also noticed, among the fallow ants, what might be termed gymnastics. On a sunny day he observed these ants raise themselves upon their hind legs, in pairs, and struggle together. These wrestlings continued several days, sometimes the whole nest engaged, and at other time only groups. None were ever wounded, and there is no doubt that it was sport.

I think we have seen enough of the habits and works of these insects to make us wonder what sort of creatures they can be, and what they have that specially adapts them for their mode of life.

The ant belongs to that class of insects which has four naked wings. Their heads are triangular-oblong, and terminate in a point more or less obtuse, and is terminated by two large jaws, termed mandibles, underneath which is the mouth. On each side are large reticulated eyes, and above are usually three smaller ones. In the fore part of the head are the antennæ, and underneath these the lower jaw. The antennæ in some are filiform, whereas others are enlarged at the extremity. The head is connected with the thorax by a narrow neck of fleshy substance. On the thorax are fixed the legs and wings. The legs are divided into the thigh, the leg, and the foot. The abdomen, a third division of the ant's body, is of an oval form, more or less pointed at the extremity. Some ants possess a sting, others are capable of emitting a poison from their abdomen. Their nervous system is the same as in other insects, that is, it consists of a chain of ganglia placed ventrally, which however becomes a little concentrated in the cephalic portion of the body.

What, then, is there in these insects which enables them to form such habitations, and that endues them with such social feelings, as we have noticed?

We have seen the tools they employ in constructing their nests, we know that their nervous system is no more developed than that of other insects, and no reason can be assigned for the wonderful sagacity which we have seen they possess.

It was announced that the Committee had settled Tuesday, July 15th, as the day for the Society's excursion, and that they should go to Chepstow and Tintern Abbey.

MEETING, JULY 24TH, 1873.

The VICE-PRESIDENT in the Chair.

The sixth and last meeting of the term was held in the Chemical Lecture Room. There were Twenty-two members present.

The Society transacted some private business, and then proceeded to elect officers for the next term.

R. M. Johnston was elected Treasurer.

There were eight candidates proposed for the Committee, from whom the following were elected :—J. Allen, W. Bean, G. Dakyns, H. Moser, T. L. Jenkins.

At a subsequent meeting of the Committee, G. Dakyns was elected Secretary.

H. Wills proposed, and G. H. Wollaston, Esq., seconded, a vote of thanks to the outgoing officers, which was carried unanimously. C. L. Ivens replied on behalf of the Committee.

This was the last meeting of the term.

Clifton College Scientific Society.

ACCOUNTS OF THE SOCIETY'S EXCURSION TO TINTERN, JULY 15th, 1873.

RECEIPTS.	£	s	d
Donation from J. F. Stone, Esq. - -	0	10	6
Subscriptions of Members - - -	18	18	0
„ Honorary Members -	2	18	0
	£22	6	6

EXPENDITURE.	£	s	d
To Steamer to and from Chepstow - -	20	0	0
„ Attendance - - - - -	0	10	0
„ Porterage of hampers - - -	0	10	0
„ Ferry-boat - - - - -	0	6	6
„ Expenses at Tintern Abbey - -	0	10	0
„ Expenses at Chepstow Castle and the Moss Cottage - - - -	0	4	0
„ Porter of the Pontoon - - -	0	1	0
„ Fees - - - - - -	0	4	0
Balance (to the Society's Funds) - -	0	1	0
	£22	6	6

Audited by J. G. GRENFELL and G. DAKYNS.

July 20th, 1873.

R. M. JOHNSTON, *Treasurer.*

THIRD TERM, 1873.

MEETING, October 9th, 1873.

The President in the Chair.

The first meeting of the term was held in the Physical Lecture Room. There were Thirty-six members present.

The President acknowledged the following donations :—A Nautilus from upper carboniferous shales of Clifton, presented by J. E. Jose, (O.C.); Copies of the Transactions from King Edward's School, Birmingham, and Highgate School; Phosphate Earth, from W. Smith, Esq.

The Committee elected the following Ordinary Members from—

THE COLLEGE.	THE JUNIOR SCHOOL.
A. D. Younghusband	W. L. Forbes
R. Sumner	X. Y. Evill
D. V. Pirie	E. A. B. Brown
C. H. Vidal	C. H. Donovan
H. F. Fox	A. W. Jose
E. Berry	
M. Heard	
W. H. Ley	
D. M. Patten	
A. W. Smyth	

The following Directors of Sections were elected :—

For the Geology Section	Mr. Grenfell
„ Archæology...	J. E. Jose
„ Botany	Mr. Wollaston
„ Zoological	(none)
„ Chemistry }	R. M. Johnston
„ Physics }	

A. D. Younghusband was elected a member of the Committee, instead of Jenkins, who had left.

C. L. Ivens (O.C.), was elected a Corresponding Member.

The President (by the request of the Committee) then proceeded to inaugurate the term by an opening address, after which Fossils and objects of interest were exhibited.

MEETING, October 30th, 1873.

The President in the Chair.

The second meeting of the term was held in the Physical Lecture Room. There were Forty-three members and visitors present.

Donations acknowledged :— Quarterly Journal of Science, and several Nos. of Geological Magazines, from F. Tuckett, Esq.; Cornish Minerals, from G. V. Cox.

The President announced that the Committee had elected Strachan, Smith, and Curry, members of the Society.

G. Dakyns then read a paper on Norway.

The President and Mr. Wollaston spoke on the paper.

The Treasurer, R. M. Johnston, read the accounts of the Society for the last term, which showed a balance of £16 : 14 : 0.

MEETING, November 6th, 1873.

The Vice-President in the Chair.

The third meeting of the term was held in the Physical Lecture Room. There were only Twenty members present.

On account of the small number of members present, Moser proposed, and Dakyns seconded, that the meeting be adjourned. The meeting was accordingly adjourned till that day week.

MEETING, November 13th, 1874.

The Vice-President in the Chair.

The fourth meeting of the term was held in the Physical Lecture Room. There were Thirty-seven members present.

Mr. Wollaston proposed that the Secretary should, for the time, take the Chair.

The Secretary then called upon Mr. Wollaston for his paper on

METAMORPHOSIS OF LEAVES IN PLANTS.

We cannot go into the smallest garden, or take a walk in the country with our eyes open, without being struck with the wonderful variety in the flowers around us. If it is in the spring, we see the hedges white with hawthorn and fringed with the catkins of the hazel, while at our feet we find primroses, hyacinths, anemones, and the queer flowers of the cuckoo-pint or arum, and the fields are golden with buttercups or white with daisies; and the orchards are glorious in the red and white blossoms which are the promise of autumn.

Or, in the autumn, we see the soft juicy apple, the prickly chestnut, the scaly filbert, and the acorn so wonderfully fitted into its cup. Who can help saying, "Thou hast made me glad through Thy works!"

But whence and wherefore all this endless variety? Is it not possible that, running through the whole apparently tangled skein, there may

be some thread which will serve as a clue in our search after the order which we know must be hidden behind this glorious exuberance of varied forms.

Long had botanists and physiologists searched in vain for the clue; but the discovery of it was reserved for one— not a laborious experimenter or deep reasoner, not a mathematician or physiologist, not even a botanist—it was John Wolfgang Göethe, the most brilliant poet of the century, the man whose poetical theory of light and colour—beautiful as it was—was an entire failure; who, by what we must call "*instinct*," hit upon that principle which I hope to explain to you to-night.

Göethe himself has left us in his poems a record of what were his own feelings with regard to the "necessity" of the existence of such a principle.

"Thou art perplexed my beloved with the thousand-fold endless confusion
Of the luxuriant wealth which in thy garden is spread;
Name upon name thou hearest, and in thy dissatisfied hearing,
With a barbarian clang one drives another along,
All the forms resemble, yet none is the same as another;
Thus the whole of the throng points to a deep hidden law,
Points to a sacred riddle. Oh! could I to thee my beloved one,
Whisper the fortunate word by which the riddle is read!"

Typical Flower.

If you take any common plant, you find the leaves either opposite to each other, or else arranged in a *spiral* up the stem. We often find many leaves opposite to each other, as in the common cleaver, and such an arrangement is called a *whorl*. In the flowers, too, of most plants, we find an arrangement in whorls. In a wild rose, an apple-blossom, or a mallow flower, we have a whorl of green sepals, then a coloured whorl of petals, then one or more whorls of stamens, and finally a whorl of pistils or ovaries. Outside the whole of these whorls we find, in some flowers, such as the thistle or scabious, a a covering of scaly leaf-like appendages called bracts. Now Göethe's idea is, that all these different parts of the flower, each performing such special functions, are in reality metamorphosed leaves brought together by the shortening of the axis, and modified in form in order to play the part required of them in the propagation of the plant.

You will, I am sure, at once see how this principle—supposing it to be true—simplifies all our confusions and difficulties. We see that in some plants the cohesion of leaves, normally separate, gives us the bell of the campanula, or the winged flower of the pea; that, in other plants, the thickening of a leaf gives us the fleshy fruit of the apple or pear; while in others, again, cultivation changes the thin filaments of the anther into the more leaf-like petals of the double rose. Thus all the various points of a plant are but developments of such an ideal monster as you see before you.

But is the principle true? Is it a fact that leaves do change after this fashion, or is the whole idea but a poetical dream? I answer—it is not a dream. It is one of the most certain and well-attested *facts*. That leaves are changed or metamorphosed to serve certain ends, there is not the least doubt. If you examine the leaf of the common garden pea, you will find that the terminal pinna has not any lamina, or blade, but consist simply of a midrib occasionally branching out and forming what is called a *tendril*. Thus, by means of an altered leaf, the plant is able to support itself.

You are, many of you, acquainted with the curious pitchers of the pitcher plant. These pitchers are leaves, the covering of the pitcher is the blade, the pitcher itself is a hollow stem. Other plants occasionally produce leaves, the edges of which cohere together and form pitchers, or funnels. They have been observed in the pelargonium, the tropœolum, and the garden pea.

There are two kinds of columbine commonly cultivated in our gardens. One kind has the flower divided into five parts, each of which has a curiously recurved spur, somewhat like a bird's head, whence the name of the plant columbine, or aquilegia. The other kind has not *spurs*, but is a much more open kind of flower, with flatter petals. These two kinds, seemingly so distinct, are not separable—the one passes into the other.

Now, not only do we find petals changing their shape, as in the columbine, but we not unfrequently find sepals and petals also becoming truly leaf-like. In roses the sepals have been seen to take a regular pinnate form, exactly similar to that of the normal leaves of the plant, and the same change occurs occasionally in the calyx of the peach, the fuchsia, the primrose, and the melon. Leafy corollas have been found in roses, cabbages, wall-flowers, mallows, cherry-blossoms, scabious, campanula, and a host of other plants.

The form of the calyx and corolla is not so unlike that of a leaf as is a stamen, or one of the carpels, but even these parts are sometimes found assuming a regular leaf-shape. The anthers of petunias are occasionally found turned into leaves, while the filament retains its normal condition; and a flower of euphorbia was observed by Dr. Masters, of which one-half of the anther was frondescent while the other was perfect. We all know the double-rose, in which the stamens are changed into petals; and how often have we been disappointed in finding that our rose had a green heart. This heart is nothing but a leafy form taken by the carpels, and occasionally a

whole tuft of leaves is seen emerging from the centre of the flower. The carpels are sometimes found lying spread out with buds, or leaflets, in the place of ovules.

In some cases the whole of the whorls of the flowers become leafy, as in the green rose, or in diplotaxis tenuifolia, a member of the cruciferous family, in which sepals, petals, stamens, and carpels, are replaced by sixteen distinct leaflets, each in its proper position.

Now, not only do we find the parts of the flower which are unlike leaves in their normal condition assuming a leaf-shape, but we also occasionally find those parts which are more leafy, assuming the form of the less leafy ones. The petals of the scarlet-runner have been found turned into stamens, as also have those of the foxglove; while in papaver bracteatum a large number of the stamens are often converted into pistils; and in double-tulips all stages of the transformation may be observed. The most curious case of such a change is that which not unfrequently occurs in the wall-flower. We sometimes find the six new carpels perfectly free, lying spread open with the rows of ovules along their inner edges; occasionally the edges are soldered together, and at other times the whole series are united together into a tube surrounding the usual carpels. We see, then, that each of the various whorls of the flower is sometimes found metamorphosed into another part, and also that they may each be metamorphosed into leaves.

These leaves, then, are the link which binds together the different parts, at first sight each so unlike the other, but which, we have seen, are really most intimately connected among themselves.

This wonderful "lucky word whereby the riddle was read," was further worked out by A. P. de Candolle, of Geneva, who, by considering some parts of the flower as degenerated, or absent by the abortion of the buds which might have formed them, and other parts as formed of more than one organ cohering together, held that all the most irregular plants may be reduced to perfect symmetry.

I should, I fear, only weary you were I to tell you of the almost endless cases in which some of the most unsymmetrical flowers known, such as the pea, the snapdragon, and the calceolaria, have been found in a perfectly regular form; of how, in some of the scrophulariaceæ some genera have five stamens, while in those which have a less number we often find either a nearly perfect, though barren one, as in pentstemon, or merely a thread often scarcely to be discovered, as in antirrhinum, or how it has been shown that in the orchideae the peculiar structure of the plant is owing to its having six stamens, of which five are usually abortive.

Is not this principle of metamorphosed symmetry a wonderful simplifier of our difficulties; does it not reduce confusion to order? such order as we find throughout the whole of nature. Not the order of the parts of a dead machine (even though it be a machine endowed with perpetual motion), but the order in which an intelligent being works, adapting his means to his ends. Does it not make the study of Botany, which many of you probably associate only with sesqui

pedalia verba and meaningless lists of names, appear something higher, something more living, something more worthy of study—even in its most intricate refinements—than it did before?

We all love flowers, but many of us hate Botany, not, I know, from any dislike of hard work—a charge which I cannot bring against this school—but either from ignorance of the ends to be obtained by its study, or of the method of study employed, or else from an ill-founded prejudice that Botany destroys all the beauty of flowers, and robs them of their poetry.

Let Göethe, the poet, answer for the poetry. I myself will answer for it that for me there is far more beauty in the lily of the valley, the rose of the hedgerow, or the gentian of the Alpine pasture, since I learned the meaning of those words of King David the poet—"The works of the Lord are great, sought out of all them that take pleasure therein."

A vote of thanks was passed to Mr. Wollaston for his paper.

W. J. Bean then read Part I. of his paper on "Iceland."

MEETING, November 27th, 1873.

The President in the Chair.

The fifth meeting of the term was held in the Physical Lecture Room. There were Thirty-five members present.

W. J. Bean then read Part II. of his paper on "Iceland."

The President announced that Mr. Fry would give a lecture on Electricity, in the Big School, on Tuesday, December 9th.

MEETING, December 9th, 1873.

The President in the Chair.

The sixth meeting of the term was held in the Big School. There were 475 members and visitors present.

Mr. Fry then gave a most interesting lecture on

THE RUHMKORFF COIL AND THE ELECTRIC DISCHARGE THROUGH RAREFIED MEDIA.

The universe is built up of material atoms, and we have every reason to believe that space, as infinite as eternity, is full—that there is no absolute void—that an absolute vacuum is an impossibility. "*Abhorit natura vacuum*" is true, in a sense that he who first uttered the dictum never dreamt of.

Now this matter, existing as it does, in a variety of forms, inorganic and organic, simple and compound, is subject to the influence of certain forces, which forces determine the condition of the material atoms, their combination, their aggregation into masses, their position in space, and again, the separation of compounds into their constituent elements, and the changes from one condition to another. In a word, all the material atoms of which the great kosmos is built up are under the control of force.

The names by which the various modes of force are known will immediately occur to you.—Heat, light, chemical action, electricity, magnetism, gravitation, and the vital force—life. Of the last mentioned force I shall say but little, but will remind you of the vast amount of work wrought by this agency, on the surface of the earth.

This vital force, this living power, this prerogative of Deity, is to our minds, perhaps the strongest evidence and manifestation of continuous creative power.

By the agency of life, all organic nature is built up from material atoms, which, by its plastic, formative power, are assimilated into those myriad forms of vegetable and animal life which exist around us.

To this agency is also due all that will and muscular energy accomplish in the world.

From the diatom, which does not ask the millionth of an inch to exist in, to the giant tree of the tropical forest—from the protococcus nivalis, of Alpine snows, to the most gorgeous of exotic flowers—from the monad to the man, the whole surface of the globe teems with life, and its solid crust speaks of the existence of life-created forms in the remote past.

In speaking of the forces of nature, I must beg you to remember, that they are invisible agents, and are only rendered apparent to our senses by the conduct of matter under their influence. Thus, we cannot see motion, we can only see a body in motion. If we place a few billiard balls close together in a line, and give a sharp blow to the outside ball at one end, the outside ball at the other end of the row will be driven off, the intermediate balls remaining stationary. The force has been communicated through each ball, through each particle of each ball in the line of force, and the existence of the force is made evident to our senses by the movement of the last ball only.

Again, we cannot see gravitation, we cannot see magnetism, we cannot see light. I need not remind you that when a sunbeam enters a dark room, through a hole in the shutter, it illuminates the dust or vapour floating about that room. The moon is seen by the light of the sun reflected from it, but where the moon is not, we see nothing, although, beyond the shadow projected by the earth, there is the full blaze of sunlight radiating into space.

Keep then distinctly before you this evening two ideas: matter, force. Matter, that which is acted upon. Force, the agent acting upon material atoms.

On the table before us are various forms of matter—metals, gases, etc., but the atoms are mute, motionless as puppets, until the showman pulls the wire and sets them in motion. Under the influence of electricity, the particles of attenuated gas, in the glass tubes, will be seen to arrange themselves in the most beautiful order. Other forms, or modes of force, will be called into being. The chemical action in the Voltaic battery (the action of the oxygen of sulphuric acid on the zinc), generates the electricity; this is convertible into magnetism, motion, heat, and light: these forces being correlative, and, like matter, absolutely indestructible.

* * * * * * *

A large induction coil was here introduced, and its construction briefly explained. The coil, made by Ruhmkorff, of Paris, gives a spark in air eight or nine inches long. The secondary wire is about twenty-four miles in length.

A number of vacuum tubes, as they are usually called, were then exhibited. They are glass tubes, containing rarefied gases—hydrogen, nitrogen, carbonic-acid gas, etc. Platinum wires are fused into the ends of the tubes, the electric discharge taking place between the wires.

Each gas has its own colour. That of nitrogen is a lovely rose, and it is doubtless to this gas, that the rose colour of the aurora borealis is due. Carbonic-acid gas gives a beautiful white light, and is remarkably luminous. The stratification in the tubes containing hydrogen gas is exceedingly beautiful. When examined by the spectroscope, the characteristic bands of each gas are easily distinguished.

The character of the discharge varies with the vacuum. As the vacuum becomes nearly perfect, the discharge ceases to pass. It thus appears that the presence of material particles is essential to the communication of the electric force.

The fluorescence of uranium and of sulphate of quinine, under the influence of the electric light, was beautifully shewn: some of the vacuum tubes containing solutions of these substances. So also was the phosphorescence of sulphuret of calcium, the salt remaining distinctly luminous some time after the spark ceased to pass.

Several tubes were caused to rotate rapidly, one experiment proving the intermittent character of the spark, and illustrating at the same time persistence of vision. A single tube, in rapid rotation, illuminated momentarily in several positions, within the eighth of a second, presented the appearance of several tubes, thus forming a most beautiful star of light.

The persistence of vision was also illustrated by the following experiment:—a series of four Leyden jars, connected with each other, were charged and discharged, almost simultaneously, with a detonating sound. The spark momentarily illuminating a disc, with devices, which was being rapidly rotated; the devices appeared with perfect distinctness, just as they would if the disc had been motionless.

In conclusion, Mr. Fry spoke of the value of scientific discovery in connection with the progress and extension of civilization. He

referred especially to discoveries in electrical science, mentioning the earliest on record, that of Thales, one of the seven sages, to whom has been attributed the discovery of the electric properties of amber. ἤλεκτρον.

As an illustration of the progress of civilization, Mr. Fry contrasted the passage of Mount Cenis, A.D. 312, by Constantine, and his legions, on his victorious march from Gaul to Rome, with the trial trip on the Fell railway, over the same pass, in August, 1867. At Susa, at the foot of the pass on the Italian side, is an old Roman arch, built in honour of Augustus. Hard by there are now a railway station and telegraph office. Nature had not changed in the fifteen and a half centuries, between the sacking of the town by Constantine, and the festive celebration of the opening of the mountain railway. The snow on the mountain peaks glitters now, as dazzlingly white in the summer's sun, as it did then,—the torrent, from its icy bed, rushes on, as madly as ever, to its ocean home,—the lightning flashes in the storm,—the wild birds scream,—and the same flowers, peeping from under their coverlid of snow, turn their many-coloured petals to the same sun, now as then.

The lecturer also contrasted the voyage of Columbus, with his Spanish caravels, and 120 sailors, in 1492, when the great navigator left the old world to sweep the waste of waters, where no sail had ever been, in search of the new; with the voyage nearly 500 years after, of the Great Eastern steamship, that huge forge-born monster, 24,000 tons burthen, with some 500 souls on board, and, in its hold, coiled like a snake, 4,000 tons of wire rope—a thread, to tie together that old world and the new.

* * * * * * *

You are classical students, and cannot read the poets and philosophers of Greece and Rome without feeling a deep interest in their myths, in their yearnings after the true and the beautiful.

Grand was the idea that the shining orbs of night were set in crystal spheres, making soft music in their revolution, on unseen axis, round the world.

> "And comes the world's wide harmony in vain upon thine ears,
> The stream of music borne aloft from yonder choral spheres?
> And feel'st thou not the measure that eternal nature keeps,
> The whirling dance, for ever held in yonder azure deeps?"

Beautiful again, was the conception of Iris, messenger of the gods, descending to earth on the rainbow, her pathway vanishing as soon as her mission is accomplished. But in your long vacation rambles, as you climb the Alps, towards the eternal snows, and see the glorious vision of Iris, with her many-coloured garments, woven of sunbeams, dancing on the spray of the ice-fed cataracts,—will it mar the vision to know that it is to the shaft of far darting Apollo, κατηβόλον Ἀπολλῶνος the sunbeams vibrating millions of miles, entering the crystal cell of the dewdrop and shivered there, that Iris owes her colours, and the bow, set in the clouds, its glory?

MEETING, DECEMBER 11TH, 1873.

The PRESIDENT in the Chair.

The seventh meeting of the term was held in the Physical Lecture Room. Twenty-eight members were present.

The meeting was called for the purpose of electing the officers for the next term.

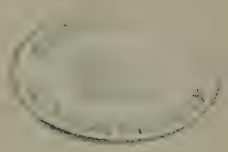
For the office of Treasurer, R. M. Johnston was elected.

For the Committee the following were elected :—G. Dakyns, H. Moser, J. Allen, and F. L. Cartwright.

G. Dakyns was afterwards elected Secretary.

This was the last meeting of the term.

APPENDIX.



CATALOGUE OF THE MINERALS

IN THE

Clifton College Museum.

The formulæ are those employed by Professor DANA in the fifth edition of his "System of Mineralogy," and are prevalent in most English and Foreign Works on the subject.

ELEMENTS.

No.	Name.	Formula.	Locality.
1246	Graphite	C.	Borrowdale
1247	....	....	Alps
1231	Sulphur	S.	Catania
1245	Do. with Gypsum ..	....	Sicily
1244	Do. with Gypsum ..	....	Bex, Switzerland
1243	Do. artificially crystallised	....	Catania
1230	Do.	....	....
1016	Copper	Cu.	Gwennap
	....	....	Cornwall
	....	....	West Bassett
	....	....	Cornwall
1026	....	....	....
1017	....	....	....
1024	....	....	....
1020	....	....	....
1014	....	....	....
1023	Do. with Quartz.. ..	....	....
1112	Gold	Au.	Hungary
1111	Do. in silver ore.. ..	....	Guanaxuato, Mexico
1113	Platina, in foil	Pt.	
	Tin smelted..	Sn.	
954	Titanium ?(Iserine) ..	Ti.	In slag, Plymouth Iron Works, Cardiff
1119	Antimony	Sb.	

SULPHIDES.

No.	Name.	Formula.	Formula.
1140	Galena	Pb S	Saxony
1141	....	....	....
1151	....	....	Mexico
1149	Do. with Calcite	....	Lorn Ferrers Mine, Leicestershire
1148	....	....	Beer Alston, Devon
1147	....	....	....
1146	....	....	Cornwall
1145	....	....	Wheal Hope, Cornwall
1143	Do. showing Slikensides	....	Derbyshire
1133	Do. Cleavage forms ..	....	....

SULPHIDES—*Continued.*

No.	Name.	Formula.	Locality.
1131	Galena. Cleavage forms	Pb S	Ashton, Bristol
1139	....	....	
1138	Do. with Cawk	....	
1128	Do. with Quartz & large Crystal of Blende ..	....	Deighton, nr. Padstow
1124	....	....	Co. Wicklow
1122	....	....	Loweswater, Cumberland
1137	....	....	
1136	....	....	
1135	Do. on Calcite	....	Alston
1129	Do. with Calcite and Carbonate of Iron..	....	
1130	....	....	Deighton, nr. Padstow
1121	....	....	
764	Pyrite	Fe S_2	Cornwall
765	....	....	
800	....	....	
783	....	....	Cornwall
735	Do. in Ironstone nodules	....	Tenby
790	....	....	Clonmel
791	....	....	....
796	....	....	
771	....	....	
772	....	....	
775	....	....	
781	....	....	Bath
794	Do. in Lias	....	
	Do. in Limestone ..	....	....
792	....	....	....
798	....	....	....
800	....	....	....
766	....	....	Castle Cock, nr. Cardiff
740	Do. in Clayslate	....	Scotland
759	....	....	
737	....	....	[borne
743	Pyrite	....	Wheal Crafty, Cam-
758	....	....	
788	....	....	
785	By some said to be pseudomorphs after Salt	....	Rhaetic beds, Aust Cliff
745	Marcasite	Fe S_2	Alston
746	....	....	....
748	....	....	Cornwall
749	Pyrrhotine or Magnetic Iron Pyrites	$Fe_2 S_3 \times 5$ FeS	Bodenmais, Bavaria
744	Mispickel	Fe S_2 + FeAs	South Wales [wall
751	....	....	Relustian mine, Corn-
767	....	....	Cornwall
756	....	....	Derbyshire
1115	Antimonite	Sb S_3	Stolberg, Harz
1116	....	....	
1114	....	....	Hungary

SULPHIDES—*Continued.*

No.	Name.	Formula.	Locality.
995	Argentite	Ag S	Valenciana
	....	....	Mexico
999	....	....	....
1000	....	....	....
1101	Proustite	$3\,Ag\,S + \left\{\begin{matrix}Sb\\As\end{matrix}\right\} S_3$	Harz
1102	Do. in Gneiss	....	Saxony
1052	Bornite	$3\,Cu_2\,S + Fe_2\,S_3$	
	....	....	South Carn Brea
1028	Redruthite	$Cu_2\,S$	Cornwall
1029	....	....	....
(2)	....	....	Near St. Ives
1032	Fahlerz	4 (Cu, Ag, Pb, &c.) S, $Sb\,S_3$	Moschel, Landsberg
1033	....	....	Erzgebirge
1034	....	....	Grisons
1051	Do. with Chalybite and Amalgam ..	....	Cornwall
1054		....	Old Crinnis Mine, Cornwall
1039	....	....	
1036	Tennantite	4 (Fe, Cu) S, $As\,S_3$	Camborne
984	Millerite	Ni S	Merthyr
994	Antimonsilber	$Ag\,S_2\,Sb$	Mexico
1223	Cinnabar	Hg S	
1226	....	....	....
1227	....	....	Zweibrücken
1228	....	....	Almaden, Spain
1196	Blende	....	Idria
1197	....	Zn S	
1198	....	....	
1199	Do. Cleavage faces ..	....	Devon
1200	....	....	West Cornwall
1201	....	....	Kapkiz, Transylvania
1203	Do. on Limestone ..	....	....
1204	Do. with Galena & Fluor	....	Cumberland
1205	Do. with Calcite	....	North Wales
1206	Do. on Iron ore	....	Harz
1207	....	....	Cornwall
1062	Towanite	....	
1045	Do. Striated crystals, probably twins	$Cu_2\,S$, $Fe_2\,S_3$	Camborne, Cornwall
(6)	....	....	Huel Buller
1046	....	....	Huel Unity
1041	Do. on Calcite	....	
1043	....	....	Siegen, Nassau
1049	....	....	
1040	Do. Hemihedral twins, on Pearl Spar	....	
1050	....	....	
1058	....	....	
	....	....	Cornwall
1059	Do. with Galena	....	Huel Clifford, Redruth
	....	....	....
	....	....	Carnbrae
		....	....

FLUORIDES.

No.	Name.	Formula.	Locality.
621	Fluor	Ca Fl.	Near Redruth
623	....	....	....
636	....	....	Wheal Buller, near Redruth
639	Do. with Galena and Pyrites	....	....
640	One Cube with a layer of Pyrite	....	Alston Moor, Cumberland
650	....	....	Derbyshire
654	Do. on a Quartz vein ..	....	Redruth
658	Do. coated with crystals of Quartz	....	Cornwall
659	....	....	Wolsendorf, Bavaria
660	....	....	Cornwall
661	Do. (Chlorophane) ..	....	Cornwall

OXIDES, EARTHS, AND ACIDS.

No.	Name.	Formula.	Locality.
26	Quartz	Si O_2	St. Ives
27	....	....	....
72	Do. including small crystals of Hydrous Oxide of Iron ..		Hotwells, Bristol
8	Do. with Pyrite (6) ..	....	Cornwall
18	....	....	....
28	Do. six-sided pyramids & prisms with alternate planes enlarged (5)	....	Wrington
46	Do. with spicules of Hydrous Oxide of Iron, in a nodule (4)	....	Bristol
65	Do. Prisms with double pyramids and Yellow Copper and Iron Pyrites (6)	....	Cornwall
16	Do. six-sided pyramids including Hydrous Oxide of Iron (5)	....	Bristol
40	Do. in Siliceous Iron Ore (5)	....	....
5	....	....	Snowdon
25	Do. Prisms and Pyramids (6,7)	....	Cornwall
55	Do. Prisms and six-sided Pyramids (5,6)	....	Bristol
30	Do. with crystals of Calcite	....	Carn Brea

Note—The Numbers in the second column refer to the Figures in Phillips' Mineralogy.

OXIDES, EARTHS, AND ACIDS—*Continued.*

No.	Name.	Formula.	Locality.
73	Quartz Minute double Pyramids (3) ..	$Si O_2$	Pentyrch, nr. Cardiff
56	Do. double Pyramids (3)	....	Cumberland
43	.... (3,5)	....	....
19	Do. Rhomboids, with angles replaced by two planes (4) ..	....	Pentarych, nr. Cardiff
1	Do. on Hydrous Oxide of Iron (4) ..	....	
30	....	....	
50	Do. Prisms and Pyramids (5,6)	....	Bristol
22	Do. minute Prisms and Pyramids (5,6)	....	
64	Do. on Clay Iron Stone (5)	....	Merthyr Tydvil
34	Do. six-sided Prism with double Pyramid (5)	....	....
51	Do on Siliceous Iron Ore (5)	....	Pentyrch, Cardiff
35	Do. from Carb. Limestone (4)	....	Pentarych, Cardiff
53	....	....	Pentyrch, Cardiff
	....	....	
23	Do. Prisms with double Pyramids (6)	....	Cornwall
51	....		Snowdon
14	Do. on black Hœmatite (6)	....	Hotwells, Bristol
29	....	....	Bristol
11	Do. hexahedral Prisms and Pyramids (6)	....	Cornwall
6	Do. with Calcite (6) ..	....	Pentarych, Cardiff
42	.... (6)	....	Snowdon
10	.... (6)	....	Cornwall
20	.... (6)	....	....
54	.... (6,7)	....	North America
75	.... (6)	....	Co. Leitrim
76	.... (6)	....	....
9	.... (1)	....	Guanaxuato, Mexico
66	.... (6)	....	Ashton
79	Do. Red Crystals (6) ..	....	Bristol
(25)	Do. coloured red ..	....	St. Just
71	.... (6) ..	....	Cornwall
(24)	Do. Amethyst	....	Wheal Unity, Cornwall
30	Do. Amethystine, in six-sided Pyramids, with Hydrous Oxide of Iron (5) ..	....	Ashley Hill, Bristol
28	Do. stalactitic Chalcedony	....	Cornwall

Note.—The Numbers in the second column refer to the Figure in Phillips' Mineralogy.

OXIDES, EARTHS, AND ACIDS—*Continued.*

No.	Name.	Formula.	Locality.
99	Quartz. Chalcedony covered with small crystals of Quartz	$Si O_2$	Cornwall
101	Do. Botryoidal Chalcedony	....	....
103	....	....	Sidmouth
98	Do. Flint, with Quartz crystals	....	
105	Do. Heliotrope: a mixture of Quartz and Earthy Chlorite	....	Isle of Rum, Hebrides
114	Hornstone: a mixture of Quartz with Alumina, &c. With Blende and Fluor	....	Devonshire
85	Do. Eisenkiesel. Ferruginous Quartz	....	Schriesheim, Bergestraw
88	Do. fat or fetid Quartz. Rolled crystals, cemented by Magnetic Iron Pyrites	....	Bodenmais, Bavaria
94	Opal. Semi-opal ..	$Si O_2 + n HO$	Hungary
95	Do. Ferruginous Opal	....	Mittelgebirge
96	Do. Memlite	....	Ménilmontant, Paris
116	Do. Siliceous Sinter ..	....	
118	....	....	Geyser, Iceland
	Quartz. Pseudomorphous after Fluor	$Si O_2$	
	Do. from a Geode ..	....	
	Do. Amethystine ..	....	Lake Superior
	Do. Amethystine in Limnite	....	
803	Hematite	$Fe_2 O_3$	Elba
804	....	....	
806	....	....	....
808	Do. on Quartz	....	....
809	Do. on Limnite	....	....
811	Do. on Quartz	....	....
813	Do. on Calcite	....	
816	....	....	Lancashire
817	....	....	....
819	....	....	Ashton
820	....	....	Harz
821	Do. with much Quartz	....	Merthyr Tydvil
436	Do. with Limnite and Baryte ..	....	Quantock Hills
(34)	....	....	St. Just, Cornwall
880	....	....	
755	Do. Pseudomorph after Pyrite in Clay-slate	....	Tyrol

OXIDES, EARTHS, AND ACIDS—*Continued.*

No.	Name.	Formula.	Locality.
752	Magnetite	FeO, Fe_2O_3	High Tor, Devon
754	....	....	
769	....	....	Sweden
826	Göthite	Fe_2O_3, HO	Lostwithiel, Cornwall
827	....	....	....
829	....	....	Restormel, Cornwall
832	....	....	....
849	....	....	Lostwithiel
853	....	....	Lancashire
	....	....	Brandon Hills, Somersetshire
836	Limnite (Brown Hematite	$Fe_2O_3, 3\,HO$	Lostwithiel
837	....	....	Lancashire
838	....	....	Cornwall
840	....	....	
890	....	....	Clifton, Bristol
822	Red Ochre		Banwell, Somersetshire
841	Jaspery Iron Ore ..		Pentyrch, Cardiff
843	Umber: a mechanical mixture of Limnite and Hydrated Oxide of Manganese with clay		Cyprus
846	Pea Iron Ore		Hungary
970	Chromite	FeO, Cr_2O_3	Unst, Shetland
951	Iserine (? Ilmentite) ..	Probably a Sesquioxide of Iron and Titanium	Riesengebirge, Silesia
948	....	....	Cornwall
949	....	....	....
912	Cassiterite	$Sn\,O_2$	....
914	....	....	St. Agnes, Cornwall
915	....	....	....
916	....	....	....
919	Do. twin crystals on Quartz	....	....
920	....	....	Bohemia
923	....	....	Levant Mine, Cornwall
935	Do. Toad's Eye, Wood-tin	....	St. Austell, Cornwall
937	Do. Wood-tin	....	Garthmine, Cornwall
939	....	....	Penzance
940	....	....	
(4)	Cuprite	$Cu_2\,O$	Near Liskeard
(5)	....	....	Wheal Bassett
1063	....	....	....
1066	....	....	Cornwall
1067	....	....	....
1068	....	....	....
1069	....	....	....
1074	....	....	....
902	Manganite	Mn_2O_3, HO	Harz
905	....	....	Restormel, Cornwall

OXIDES, EARTHS, AND ACIDS—*Continued.*

No.	Name.	Formula.	Locality.
906	Manganite	$Mn_2 O_3$, HO	Restormel, Cornwall
907	....	....	Devonshire
909	....	....	....
982	Earthy Cobalt (Asbolane)	CoO, 2 MnO_2 + 4 HO	Saalfeld, Saxony
927	Wad	MnO_2–MnO–CaO–BaO–HO	Devonshire
244	Corundum	$Al_2 O_3$	Thibet
245	....	....	China
246	....	....	Carnatic
247	....	....	....
248	....	....	....
274	Spinelle	MgO, $Al_2 O_3$	Ceylon
275	....	....	....
277	.... (2)	....	....
278	.... (1,2)	....	....
281	.... (4)	....	....
288	Do. Black Octohedra with Brown Chondrodite 2 (MgO, 3 SiO_2) + MgF ..	....	New Jersey
257	Gahnite	(Zn,Fe,Mg)O,$Al_2 O_3$	Fahlun
258	Do. in Talc-slate ..	....	....

SILICATES.

No.	Name.	Formula.	Locality.
314	Zircon, rolled crystals	ZrO_2 SiO_2	Ceylon
315	Do. rolled four-sided Prisms	....	....
316	Do.(Hyacinth) (with Pyramid faces: P, n, e. 4)	....	....
260	Topaz, rolled crystal..	6 (Al_2 O_3, SiO_2) + AlF_3 + SiF_2	Tasmania
263	Do. yellow	....	Brazil
265	....	....	Schneckenstein,Saxony
266	Do. with Quartz and Felspar	....	Mourne Mts. Down
267	Do. (faces: M, P, b2. 4)	....	
268	....	....	
270	Do. with Quartz, Felspar, & Clevelandite	....	....
272	Do. variety called Pycnite with Mica	....	Pennsylvania
255	Staurolite with Kyanite	4 $(Al\ Fe)_2$ O_3, 3 SiO_2	St. Gothard

NOTE.—The Numbers in the second column refer to the Figures in Phillips' Mineralogy.

SILICATES—*Continued.*

No.	Name.	Formula.	Locality.
121	Garnet (Almandine or precious Garnet	$3*RO, 2SiO_2 + R_2\dagger O_3 SiO_2$ *R=Fe, Ca, Mg Mn †R=Al, Fe, Cr	Greenland
124	Do. in Rhombic Dodecahedra (1) ..	....	Grisons, Switzerland
126	Do. with Felspar ..	....	Spain
128	Do. Dodecahedra, with planes P, k, i, with Calcite (5)..	....	
132	Do. (Colophonite) with Calcite and Coccolite	....	North America
134	Do. in Mica-slate ..	....	Scotland
145	Idocrase (Vesuvian). Faces: M small, d, e, P, al, a2, a3, c ..	$3\ CaO, 2\ SiO_2 + Al_2\ O_3, SiO_2$	Vesuvius
144	....	....	
142	Do. with Calcite.. ..	....	River Wilui, Siberia
147	....	....	Monte Monzoni, Tyrol
(24)	....	....	Tellemarken, Norway
133	Allochroite, massive ..	....	
135	Do. in minute Dodecahedra		Norway
137	....		Okehampton
163	Epidote, largeoblique Prisms, with dark Hornblende ..	$3\ (Ca, Mn, Fe)\ O, 2\ SiO_2 + 2\ R_2 * O_3, SiO_2$ *R=Fe, Al, Mn	.... Arendal, Norway
362	Felspar (Orthoclase)..	$KO, 3\ SiO_2 + Al_2\ O_3, 3\ SiO_2$	
366	....	....	
369	....	....	Tyrol
376	Do. in Claystone Porphyry	....	Mourne Mts. Ct. Down
	....	....	St. Agnes, Cornwall
378	Do. Red, with Quartz	....	
381	....	....	Spain
385	Do. compact	....	Bohemia
370	Do. with Mica, black Quartz, and white crystals of Clevelandite	....	Braid Hills, Edinburgh Mourne Mts.
360	Do. Adularia: Moonstone	....	Ceylon
382	Do. Decomposed: Porcelain Clay ..	....	Cornwall
419	Labradorite	$CaO, SiO_2 + Al_2 O_3, 2\ SiO_2$	Labrador
420	....	....	
444	Saussurite: probably impure Labradorite	....	Arendal, Norway
		....	Cornwall
422	Albite. With Quartz and Mica	$NaO, 3\ SiO_2 + Al_2 O_3, 3\ SiO_2$	Killiney, Co. Dublin

Note—The Numbers in the second column refer to the Figures in Phillips' Mineralogy.

SILICATES—*Continued.*

No.	Name.	Formula.	Locality.
456	Tourmaline (Schorl) with Siliceous Oxide of Iron ..	BO_3, - SiO_2, - KO, -NaO,- CaO,- Mgo, - FeO, - Al_2 O_3, - Fe_2 O_3	Bovey, Devon
460	....	....	Logan Rock, Cornwall
343	Leucite. In vescicular lava	KO, SiO_2 + Al_2 O_3, 3 SiO_2	Vesuvius
344	Do. Eicositetrahedra	....	....
327	Mica, Black	KO, 3 SiO_2 + Al_2 O_3, 3 SiO_2	Siberia
329	....	....	....
334	Do. in schist with Garnet & Staurolite	....	Glenmatur, County Wicklow
335	Do. six-sided Prisms..	....	Siberia
338	Do. diverging Laminæ in Quartz	....	Scotland
339	Do. in Quartz	....	Tyrol
342	Do. (Rubellan) with Augite	....	Bohemia
402	Lepidolite (Lithia-mica)	2 LiO, SiO_2 + 3 Al_2 O_3, 2 SiO_2 + LiF	North America
200	Hornblende.Stellated Prisms in Mica Slate	MgO-CaO,-FeO-SiO^2	Edenville, New York
201	Do. Brown crystals .	....	....
203	Do. In Hornblende-slate	....	
204	Do. (Tremolite) Flat Prisms in Quartz	....	Sweden
206	Do. (Tremolite). In Dolomite	....	New York
208	Do. (Tremolite). Granular & Fibrous	....	Russia
210	Do. Fibrous, radiating	....	St. Gothard
211	Do. Crystallised in Talc	....	Zillerthal, Tyrol
213	....	....	Norway
215	Do. Asbestiform Actinolite	....	Scotland
216	Do. (Actinolite) with Octohedra of Oxide of Iron	....	High Tor, Devon
220	Do. (Actinolite) Asbestiform, compact	....	Cornwall
221	....	....	....
228	Do. (Asbestos)	....	....
229	Do. (Asbestos) on Serpentine ..	....	....
231	Do. (Mountain Cork)	....	Scotland
188	Wollastonite.Lamellar, fibrous, with blueish Calespar and Garnets ..	CaO, SiO_2	Dognatska, Hungary
232	Hypersthene	(Mg Fe) O, SiO_2	Balantrae, Ayrshire
238	Bronzite	....	Tryol

SILICATES—*Continued.*

No.	Name.	Formula.	Locality.
239	Bronzite	(Mg Fe) O, SiO_2	Tyrol
178	Cordierite. In Quartz with Blende, Mica, and Pyrite.. ..	2 (MgO, SiO_2) + 2 Al_2O_3, 3 SiO_2	Bodenmais, Bavaria
356	Do. (Pinite) on Felspar	....	Killiney, Co. Dublin
197	Coccolite		Norway
198	....	....	....
928	Rhodonite. With veins of Pyrolusite	MnO, SiO_2	Devonshire
929	....	....	Lothringen
295	Chondrodite. (Humite)	2 (MgO, 3 SiO_2) + MgF	New Jersey
292	Olivine. Rolled crystals	2 M_2O, SiO_2	Tahiti
323	Beryl. Six-sided prisms	Al_2O_3, 3 SiO_2 + 3 GO, SiO_2	Iceland
953	Sphene	2 CaO, SiO_2 + CaO, 2 TiO_2	Maria Kirch
446	Scapolite	3 (3 CaO, SiO_2) + 2 (Al_2O_3, 3 SiO)	
412	Nepheline (Sommite)	4R*O, SiO_2 + 4Al_2O_3, 5 SiO_2 * R=Na, K, Ca	Somma
348	Andalusite. Amorphous and in six-sided prisms with Quartz	Al_2O_3, SiO_2	Ireland
184	Spodumene. Lamellar crystals	3 LiO, SiO_2 + 4Al_2O_3, SiO_2	

HYDROUS SILICATES.

No.	Name.	Formula.	Locality.
149	Prehnite. Amorphous	2 (CaO, SiO_2) + Al_2O_3, SiO_2 + HO	Fassa Thal, Tyrol
150	....	....	....
151	Do. radiating	....	Reichenbach, Upper Palatinate
155	Stilbite	CaO, 3 SiO_2 + Al_2O_3, 3SiO_2 + 6HO	Farœ
156	Do. on Trap	....	Lochwinnock, Glasgow
159	Heulandite. With pearly lustre. Faces P, M, T.	CaO, 3 SiO_2 + Al_2O_3, 3SiO_2 + 5HO	Farœ
234	Schillerspar. Very small bright plates, in Serpentine ..	(Mg Fe) O, SiO_2 + HO	Portsoy, Banffshire
235	....	....	....
424	Analcime. Transparent twenty-four-sided crystals. Fig. 3	NaO, SiO_2 + Al_2O_3, 3 SiO_2 + 2 HO	Iceland
435	....	....	Fassa Thal, Tyrol

HYDROUS SILICATES—*Continued.*

No.	Name.	Formula.	Locality.
404	Mesotype (Natrolite)	$NaO, 2HO + Al_2O_3, 3SiO_2$	Giant's Causeway
405	....	....	....
407	....	....	Hohentwiel in Högau, Wurtemberg
406	Do. (Lehuntite)		Salough Crags, Antrim
408	Thomsonite	$3(CaO, SiO_2) + 3(Al_2O_3, SiO_2) + 7HO$	Kilpatrick, near Dumbarton
350	Phillipsite. Lining amygdaloid cavities	$R^*O, SiO_2 + Al_2O_3, SiO_2 + 5HO$. *R =Na, K, Ca	Isle of Magee, County Antrim
389	Chlorite. In 8 hedra, pseudomorphous after Red Oxide of Copper	SiO_2—Al_2O_3—FeO—MgO—HO	Cornwall
391	Green Earth (a variety of Chlorite)		Verona
387	Agalmatolite		China
347	Talc (Nacrite)	$MgO, 2SiO_2 + HO$	County Wicklow
394	Do. With Fluor and Apatite	....	St. Austell
397	....	....	
399	....	....	Brazil
401	Do. In Schist	....	....
956	Cerite (doubtful) ..	$2CeO, SiO_2 + 2HO$	Shetland
1095	Chrysocolla..	$CuO, SiO_2 + 2HO$	Cornwall
1097	....	....	Siberia
1098	....	....	Nr. Rouskear, Cornwall
1212	Smithsonite	$2ZnO, SiO_2 + HO$	
	Prehnite	$2(CaO, SiO_2 + Al_2O_3, SiO_2 + HO$	Scotland
411	Gmelinite	$NaO, SiO_2 + Al_2O_3, SiO_2 + 6HO$	County Antrim
453	....	....	Germany
449	Chabasie	$CaO, SiO_2 + Al_2O_3, 3SiO_2 + 6HO$	Glencoe
452	....	....	Bohemia
298	Serpentine	$3MgO, 2SiO_2 + 2HO$	Puster Thal, Tyrol
300	....	....	Baireuth
303	....	....	
304	....	....	Cornwall
305	....	....	Portsoy, Banffshire
306	Do. With Calcite ..	....	Elba
307	....	....	
181	Brewsterite. Oblique Prisms in Calcite	$R^*O, 2SiO_2 + Al_2O_3, 3SiO_2 + 5HO$ R=Sr, Br, Ca	Strontian, Argyllshire
179	Harmotone	$BaO, 2SiO_2 + Al_2O_3, 3SiO_2 + 5HO$	....
182	Do. Twin crystals in Calcite and Galena	....	Andreasberg, Harz
310	Steatite		

ANHYDROUS CARBONATES.

No.	Name.	Formula.	Locality.
531	Calcite. Acute 6-hedral pyramids	CaO,CO_2	Ashton, nr. Bristol
544	Do. 6-hedral prisms and pyramids with 3-hedral summits	....	Derbyshire
532	....	....	
567	....	....	Portland
540	Do. 3-hedral pyramids with truncated edges ..	....	Pentyrch, Cardiff
541	Do. Macled crystal ..	....	....
552	Do. Cleavage rhombohedral. Phosphorescent when heated	....	County Kildare
470	Do. Cleavage rhombohedral	....	....
471	Do. Cleavage forms with Asbestos ..	....	Tyrol
553	Do. On Quartz	....	St. Just, Cornwall
555	Do. In Granite. Phosphorescent	....	Killiney, Co. Dublin
558	Do. (Schierfer Spar)..	....	Cumberland
526	....	....	....
551	Do. Cleavage forms ..	....	....
538	Do. Macled crystal ..	....	Castell Coch, Pentyrch
506	Do. In Bath Oolite ..	....	Box, nr. Bath
560	Do. Fibrous	....	Alum Bay
550	Do. Very acute pyramids	....	Wiesloch, Heidelberg
548	Do. Acute 12-hedra ..	....	....
496	Do. Obtuse rhombohedra, on Quartz with minute specks of Galena	....	
475	Do. Obtuse rhombohedra with curved faces, and with Bitterspar & Malachite	....	Llanhidlo, N. Wales
494	....	....	Castell Coch, Pentyrch
504	Do. Rhombohedra ..	....	Ashton Hill, Bristol
514	Do. In Bath Oolite ..	....	Box, nr. Bath
501	....	....	Finglas, Co. Dublin
503	Do. In New Red Sandstone	....	Near Chepstow
543	Do. On Quartz	....	Alston
530	....	....	Bristol
518	....	....	....
502	....	....	
505	Do. Part of a six-sided pyramid (+cleavage plane) with small acute rhombohedra	....	Plymouth

ANHYDROUS CARBONATES—*Continued.*

No.	Name.	Formula.	Locality.
535	Calcite. Dog-tooth Spar	CaO, CO_2	Durdham Down
566	Do. In Oolite	....	Near Bath
519	Do. Macled crystals with many faces	....	Derbyshire
499	Do. Obtuse rhombohedra on Quartz	....	....
488	Do. With Galena and Chalybite ..	....	
484	....	....	
495	....	....	Castell Coch, Pentyrch
480	....	....	
478	Do. 6-hedral prisms ..	....	Andreasberg, Harz
490	Do. With Pyrite and Blende	....	Derbyshire
511	....	....	
521	Do. Prisms with 3-hedral summit	....	Bristol
(18)	....	....	Camborne
(19)	....	....	Near Camborne
(20)	....	....	Near Liskeard
559	Do. (Agaric Mineral) from a flint ..	....	Bally Castle, County Antrim
561	Do. (Aphrite) with Gypsum	....	Mansfeld, Thuringia
590*	Tufa, Carbonate of Lime deposited by water. Coloured by Copper	....	
579*	Limestone, with Lithostrotion ..	....	Bristol
581*	....	....	Ireland
580*	Veins of Carbonate of Lime in Clay Iron-stone	....	Weymouth
582*	Limestone, with Manganese ..		
588*	....	....	Plymouth
569*	Marble	....	Italy
571*	....	....	....
592	Arragonite	....	Bohemia
600	....	....	....
601	....	....	Ilfracombe
602	....	....	Buckfastleigh, Devon
605	Do. In Basalt	....	County Antrim
603	....	....	Cornwall
591	....	....	Neuhof, Bohemia
598	Do. Stalactitic	....	Corsica
609	Dolomite	$\{CaO, CO_2 + MgO, CO_2\}$	Bankowsky, Siberia
610	....	....	
614	....	....	Sunderland
700	Barytocalcite	$BaO, CO_2 + CaO, CO_2$	Alston
697	Witherite	BaO, CO_2	....
691	Ankerite		Tyrol

* These Specimens are properly accounted Rocks.

ANHYDROUS CARBONATES.—*Continued.*

No.	Name.	Formula.	Locality.
1854	Spathose Iron (Chalybite)	FeO, CO^2	Wheal Buller, near Redruth
855	Do. With Quartz, Limonite, & Göthite	....	Lostwithiel, Cornwall
858	Do. Hollow obtuse rhomboids on Quartz	....	Cornwall
860	Do. Obtuse transparent rhombohedra	....	Forest of Dean
862	Do. Rhombohedra on stalactitic Iron	....	....
863	....	....	....
865	Do. With Quartz ..	....	....
868	Do. Minute rhombohedra on Quartz	....	Roskear, Camborne
870	Do. With Pyrite ..	....	Cornwall
871	Do. Lenticular crystals on Quartz ..	....	....
874	....	....	Botallack Mine, Cornwall
875	....	....	Harz
877	Do. Mass of rhombohedra whose acute angles seem to project	....	Huel Cock, St. Just, Cornwall
879	....	....	Nr. Hanau, Frankfort
881	Do. Clay Iron-stone, impure Spathose Iron, rich in Fe	....	Hard Mine, Risca, Newport
882	Do. Poor in Fe	....	Soap Mine, Risca
887	Do. With veins of purer mineral ..	....	Forked Mine, Risca
1153	Cerussite. Macled crystals	PbO, CO_2	County Wicklow
1154	....	....	....
1156	....	....	Scotland
1157	....	....	Newlands, Cumberland
1160	....	....	Cornwall
1161	Do. With Leadhillite	....	Ballycoras Mine, County Dublin
1162	....	....	Münsterthal, Tyrol
1164	....	....	Leadhills
1166	....	....	....
1167	Do. With Quartz coated with Lead	....	Pentyre Glase, Cornwall
1213	Calamine	ZnO, CO_2	Somersetshire
1214	....	....	Derbyshire
1215	....	....	....
1217	....	....	Alston
1220	Do. Acute pyramid ..	....	Cornwall
930	Diallogite	MnO, CO_2	Bohemia

HYDROUS CARBONATES.

No.	Name.	Formula.	Locality.
1085	Malachite. Pseudomorph after Cuprite	$CuO, CO_2 + CuO, HO$	Chessy, nr. Lyons
1086	....	....	Mexico
1087	Do. On Iron-ochre ..	....	Siberia
1088	Do. With Barytes ..	....	Clevedon
1089	....	....	Cornwall
1092	....	....	Buckingham Mine, nr. Bridgwater
1098	Do. With Black Copper	....	Somersetshire
	Do. Impregnating Sandstone	....	Doddington, Somersetshire
1077	Chessylite (Azurite)	$2(CuO, Co_2) + CuO, HO$	Chessy, nr. Lyons
1078	....	....	....
1079	....	....	....
1080	....	....	....
1082	....	....	Falmouth
1083	....	....	Guanaxuato, Mexico

ANHYDROUS SULPHATES.

No.	Name.	Formula.	Locality.
662	Anhydrite (Karstenite)	CaO, SO_3	Tyrol
664	....	....	Salzburg
668	....	....	Lockport, New Jersey
669	....	....	....
703	Baryte. With Calcite	BaO, SO_3	
705	....	....	Germany
708	....	....	Dufton, Cumberland
709	....	....	County Wicklow
711	....	....	
714	Do. Fibrous	....	Baltenberg, Pfalz
715	....	....	Schriesheim, Bergstraw
717	Do. Botryoidal	....	Clifton
	....	....	Connington Park, Bridgwater
718	Do. Cawk or Earthy Baryte	....	Banwell Cave, Somersetshire
720	Celestine	SrO, SO_3	Bitton, nr. Bristol
721	....	....	Pile Hill, Bristol
725	Do. On a Flint	....	Paris
728	....	....	Totterdown, Bristol
731	....	....	Leigh, Bristol
733	....	....	Bristol
1187	Anglesite	PbO, SO_3	Ballycoras, County Dublin
1188	....	....	Caldbeck Fell, Cumberland
1189	....	....	Scotland

HYDROUS SULPHATES.

No.	Name.	Formula.	Locality.
670	Gypsum	$CaO, SO_3 + 2\,HO$	Harz
674	Do. Twins	....	London Clay
675	....	....	
677	Do. In acicular crystals with Rock Salt	....	Sabzburg
679	Do. Group of twins ..	....	Paris
687	....	....	Cheshire
688	....	....	Hasmersheim, Neckar
689	....	....	
	....	....	Keuper beds, Penarth Cliff, Glamorgan
462	Websterite	$Al_2O_3, SO_3 + 9\,HO$	Newhaven, Sussex
723	Alumite	$KO, SO_3 + 3Al_2O_3, SO_3 + 6\,HO$	Tolfa, nr. Rome

ANHYDROUS PHOSPHATES, ARSENIATES, &c.

No.	Name.	Formula.	Locality.
618	Apatite. On Felspar	$3(3\,CaO, PO_5) + Co\,\{Cl.\ F.\}$	Cornwall
619	....	....	
620	Do. Pale green crystals, with Hornblende, in Limestone	....	
1168	Pyromorphite	$3\,(3PbO, PO_5) + Pb\,Cl$	Scotland
1169	....	....	Cornwall
1170	....	....	....
1173	....	....	....
1174	Do. On Quartz	....	Hausbaden
1175	....	....	Newtownwards, County Down
1178	....	....	Cornwall
1180	....	....	Caldbeck Fell, Cumberland
1181	....	....	Cornwall
1182	....	....	Caldbeck Fell
934	Triplite	$4\,(Fe, Mn)\,O, PO_5$	Limoges
899	Wolfram	$(FeO, MnO)\,WO_3$	Staffordshire
900	....	....	St. Agnes, Cornwall
1191	Wulfenite	PbO, MoO_3	
1192	Lehmanite	PbO, CrO_2	Beresof, Siberia
693	Boracite	$2\,(3\,MgO, 4\,BO_3) + Mg\,Cl$	Kalkberg

HYDROUS PHOSPHATES, ARSENIATES, &c.

No.	Name.	Formula.	Locality.
958	Uranite (Torberite) ..	$\{(Ca, Cu)O, 2\,PO_5 + 2\,U_2\,O_3 + 8\,HO\}$	Pfalz
962	....	....	Cornwall
963	....	....	....
964	....	....	....
966	....	....	....
968	....	....	....
969	....	....	....
892	Vivianite	$8\,FeO, PO_3 + 8\,HO$	Wheal Falmouth nr. Truro
894	....	....	St. Just
464	Wavellite	$\{3\,(4\,Al_2\,O_3, 3\,PO_5 + 18\,HO) + Al_2\,F_3\}$	Devonshire
465	....	....	Ireland
1104	Olivenite	$\{3\,CuO, \overset{As}{P}\}\,O_5 + CuO, HO\}$	Cornwall
1106	....	....	Anglesea
1100	Livoconite	$\{2CuO, AsO_5 + 2Al_2\,O_3, AsO_5 + 2\,HO\}$	Cornwall
1102	....	....	
897	Pharmacosiderite (Würfelerz) ..	$\{3\,FeO, AsO_5 + 3\,Fe_2\,O_3\,AsO_3 + 18\,HO\}$	....
1107	Klinoclase	$\{3\,CuO, AsO_5 + 3\,CuO, HO\}$	....
1108	....	....	....
1109	....	....	....

COAL, &c.

No.	Name.	Formula.	Locality.
1233	Cannel Coal		Lancashire
1234	Brown Coal		Bovey Tracey
1235	....		....
1239	Amber. In Lignite ..		Hesse
1241	Hatchettine. On Spathose Iron-ore		Merthyr Tydvil
1247	Elastic Bitumen. A variety of Naphtha		Derbyshire
1248	Asphalt. Hardened Naptha		Pitch Lake, Trinidad
1249	Horn Coal		Risca, Newport
1250	Dysodile		Mellili, Syracuse
1251	Retinasphalt		Bovey Tracey

TRANSACTIONS, 1874,

AND PART OF 1875.

Owing to a combination of several unfortunate circumstances, the Transactions for the year 1873 were not published in the May Term.

To these are now added the Transactions for 1874. The Society as a whole did not do much work in that year; but the paper by R. Montgomery, and his map of Unst, not only the geology but also the topography of which are entirely his own work, confer a distinct lustre on its proceedings. It is pleasant, too, to insert the paper by W. A. Smith, O.C.—an evidence that our old members bear us in mind.

G. H. W.

Michaelmas, 1875.

TRANSACTIONS

OF THE

CLIFTON COLLEGE SCIENTIFIC SOCIETY.

FIRST TERM, 1874.

MEETING, JANUARY 22ND, 1874.

The PRESIDENT in the Chair.

The first meeting of the term was held in the Chemical Lecture Room. There were Twenty-eight members and visitors present.

The President exhibited various fossils.

W. A. Smith, (O.C.) read a paper on "Aniline Colours."

A vote of thanks to Smith was proposed by the President and seconded by R. M. Johnston. The motion was carried by acclamation.

The Treasurer of the Society, R. M. Johnston, read the accounts, and stated that the subscription for this term would be 2s. for the Upper School, and 1s. 6d. for the Junior School.

G. Dakyns proposed and R. M. Johnston seconded, "that in future visitors should be admitted by ticket only." This motion was carried unanimously.

The President gave notice that Mr. Stoddart would read a lecture in Big School in a few weeks.

The meeting then adjourned.

ANILINE COLOURS.

Illustrated by many experiments.

Not only some of our most brilliantly-coloured dyes, but also many bodies used for numerous purposes in the arts are obtained from one of the bye-products in the distillation of coal, viz. : coal tar.

When coal is subjected to dry distillation, gases are driven off, which after being purified form ordinary coal gas, while coke remains in the retorts. Besides these products, liquids are condensed in the receivers. These, on standing, separate into two layers, the aqueous one of which contains chiefly ammonia, while the composition of the dark oily layer or tar is very complicated and varying. When distilled, the water and ammonia are first driven off, and the distillate may then roughly be divided into naphtha, creosote, and anthracene oil, while a residue of pitch remains behind. The *naphtha*, which comes over first and which is lighter than water, is treated with sodium carbonate, thereby precipitating sodium phenate or carbolate, from which, on acidifying with sulphuric acid, carbolic acid or phenol is produced. This latter is much used now as a disinfectant, for dressing wounds, for preparing picric acid, &c. The liquid which is left, after treating the naphtha with sodium carbonate, is distilled, when it gives first of all crude benzol, then solvent naphtha, and lastly heavy or burning naphtha. The *creosote* portion of the distillate yields naphthalene and liquid creosote, which is much used for pickling timbers and for burning into lamp black. From the *anthracene oil*, anthracene crystallises out, and the oil that is left is used for greasing machinery.

It is of benzol and anthracene I wish particularly to speak. Benzol or benzene or phenene is a colourless, volatile, and highly inflammable liquid, burning with a bright smoky flame. From a consideration of its vapour, density, analysis, and chemical re-action, the formula $C_6 H_6$ has been assigned to it. If fuming nitric acid be added to it a very violent reaction ensues, unless care be taken, and a brown liquid is formed. If this is poured into water, a yellow oil, which is nitrobenzol, is obtained. This is used for coarse perfumery, under the name of essence of miobane. It is from this that aniline and hence aniline colours are obtained.

In 1826 Unverborben found among the products of the dry distillation of indigo, a base, which he named "crystalline," from the ease with which some of its salts crystallised.

In 1834 Runge found a body in coal tar oil, which he named "kyanol," from the blue colour which it gave with bleaching powder.

In 1840 Fritsche showed that anthranilic acid, a derivative of indigo, decomposed, on being heated, into carbon, dry oxide, and a basic substance, which he called "aniline," from *anil*, the Portuguese name for indigo.

In 1842 Zinin obtained what he called "benzidam," by the reduction of nitrobenzol by sulphide of ammonium.

In 1843 Hofmann showed that all these four bodies were one and the same base, for which he kept the name of "aniline."

For manufacturing purposes aniline is always got from nitrobenzol, by reducing it with iron turnings and acetic acid. It is a somewhat oily, colourless liquid, of a faintly aromatic smell, and burning with a bright flame. Its characteristic property, however, is that it gives,

by means of certain re-agents, gorgeous colours, which are called aniline colours.

A weak solution of bleaching powder gives a purple colour. This fact, Runge, in 1835, had discovered, as I have before mentioned. Some time after, Brissenwitz showed that by oxidising aniline with chromic acid, a blue compound could be obtained. This was isolated by Perkin, in 1856, and called mauve. He showed that it was a colouring matter capable of being fixed upon fabrics, and thus laid the foundation of the vast industry of aniline colours.

By the action of mercuric chloride, stannic chloride, arsenic oxide, &c., on aniline, a beautiful red colour is obtained—a salt of a base called rosaniline being formed. The salts are called magentas, rosaniline itself being colourless. They are identical with the crimson colour which Hofmann obtained in 1858 from aniline, by treating it with tetrachloride of carbon. Hofmann has also shown that pure aniline gives no red colour, that it is formed only when a mixture of aniline and toluidine is used. Crude aniline oil contains such a mixture.

If we add the formula of one molecule of aniline to that of two of toluidine, and subtract six atoms of hydrogen, we get the formula of the colourless base, rosaniline, thus :—

$$C_6 H_5 H_2 N + 2\, C_7 H_7 H_2 N - 3\, H_2 = C_{20} H_{19} N_3$$

or

$$\left.\begin{matrix} C_6 H_4 \\ C_7 H_6 \\ C_7 H_6 \\ H_2 \end{matrix}\right\} N_3$$

This base combines with acids in several proportions. The salts with one equivalent of acid are very stable and noted for their beautiful colours. The salts with three equivalents of acid are less stable and far more soluble in water and alcohol.

By heating a salt of rosaniline with aniline, 3 H are replaced by 3 $C_6 H_5$ and we obtain a beautiful blue, which is triphenyl rosaniline or standard blue (Paris or Lyons blue). Nicholson found that just like indigo it could be dissolved in strong sulphuric acid. Triphenyl rosaniline, sulphuric acid or soluble blue—a valuable dye—is thus obtained. Mono and diphenyl rosaniline are also known. By the action of methyl and ethyl iodides on rosaniline or its salts, we can get corresponding derivations. Some of these possess beautiful tints (Hofmann's colours), and by carrying the reaction to different stages different tints are obtained.

Anthracene, $C_{14} H_{10}$, is the other product of coal tar I wish particularly to speak of. In the pure state it has a dazzling white lustre, and a beautiful violet fluorescence. It is from this that the dye alizarin is now obtained in large quantites. Alizarin exists as glucoride in madder root, which latter has been known for a very long time as a dyeing material, from which many different colours can be obtained. The history of the chief colouring principle of madder is admirably told in Russel's address to the Chemical Section of the British Association for 1873.

In 1827 Colin and Robiquet obtained the true colouring principle of madder tolerably pure. They called it alizarin, from the Levant name for madder.

In 1848 Schunck gave it the formula $C_{14}\ H_{10}\ O_4$. He found that there was no trace of alizarin in the fresh root, but that in the cells of the living plant there was a substance called rubian, which splits up into sugar and alizarin by the action of a substance which exists in the root.

In 1850 Wolff and Strecker, by the formula they gave it, imagined that it was closely related to naphthalene. We now know, however, that their formula was wrong.

In 1785 Hofmann obtained the calcium salt of quinic acid from cinchona bark, and from this quinone can be obtained. Quinone, $C_6\ H_4\ O_2$, can be looked on as benzene, $C_6\ H_6$, in which two atoms of hydrogen are replaced by the dyad grouping, O''_2.

In 1868 Carl Graebe saw that many other quinones could be formed, and Graebe and Lieberman then looked on alizarin as a derivative from a quinone, and to have the formula $C_{14}\ H_6\ (O_2)''\ (HO)_2$, because they saw that it had many properties in common with other quinones. They have been able to establish their view. Anthraquinone was obtained from anthracene. It was then converted into the bibromanthraquinone, $C_{14}\ H_6\ Br_2\ O''_2$. On boiling this with potash at a high temperature, it became violet, and, on acidifying, alizarin separated out in yellow flakes. Since bromine is expensive, Perkin heats the alizarin with sulphuric acid thereby converting it into sulpho-compound, $C_{14}\ H_6\ (HSO_3)_2\ O''_2$. From this the calcium salt, $C_{14}\ H_6\ Ca\ (SO_3)_2\ O''_2$, is obtained; then the sodium salt, $C_{14}\ H_6\ (Na\ SO_3)_2\ O''_2$. This sulpho salt is then decomposed by caustic soda, giving the sodium salt of alizarin $C_{14}\ H_6\ (NaO)_2\ O''_2$, and lastly from this solution alizarin is precipitated by an acid, $C_{14}\ H_6\ (HO)_2\ O''_2$.

Thus chemists have found a use for coal tar, saving hundreds of acres of land, which can be devoted to the cultivation of other products than madder.

MEETING, February 12th, 1874.

The President in the Chair.

The second meeting for the term was held in the Physical Lecture Room. There were Thirty-one members and visitors present.

The President acknowledged a donation of Abyssinian Drawings, presented by H. E. Darley, (O.C.)

G. H. Wollaston, Esq., Vice-President of the Society, then read a paper upon "Nodules and Concretions." The President made some remarks upon the subject of this paper.

The meeting adjourned.

ABSTRACT
OF PAPER ON NODULES AND CONCRETIONS.

These may be simply divided into nodules of infiltration and nodules of concretion.

The manner of formation of the first is similar to that of mineral veins, they were probably deposited from solutions aided by electrical currents. But it is apparently impossible satisfactorily to account for the fractured and recemented state of many nodules. The most beautiful of the commonest nodules of infiltration are the agates, which consist of silica coloured with other oxides.

Concretions, properly so called, are in many respects similar to crystals. The mineral particles which form them seem to have had sufficient freedom to move towards each other, while the medium through which they were disseminated was too dense to allow them to assume a crystalline form. In some clays we find crystals of gypsum and calcareous nodules: the former were probably first formed.

Again, we find that some concretions— as of calcite and pyrite— are internally crystalline.

The paper was illustrated by a large number of beautiful specimens from the collections of the Society and of Mr. Wollaston.

MEETING, February 26th, 1874.

The President in the Chair.

The third meeting for the term was held in the Physical Lecture Room. There were Twenty-eight members and visitors present.

The President exhibited and described a large number of fossils from Clifton.

H. Moser read a paper upon "Salmonidœ." At the conclusion of this paper, the President and G. H. Wollaston, Esq., the Vice-President, made some remarks upon the subject.

On the proposal of R. M. Johnston, seconded by the President, W. Becker, Esq., was elected an honorary member of the Society.

The Meeting then adjourned.

MEETING, March 26th, 1874.

The President in the Chair.

The fourth meeting for the term was held in the Chemical Lecture Room. There were forty-six members and visitors present.

The President exhibited some fossils.

J. Swinburne then read a paper on "Combustion," which he illustrated by several very successful and effective experiments.

The President made some remarks upon this paper at its close.

R. M. Johnston had been announced to read a paper upon "Gas," but on account of the lateness of the hour it had to be postponed.

The meeting then adjourned.

MEETING, April 4th, 1874.

The President in the Chair.

The fifth meeting for the term was held in Mr. Grenfell's room. There were Twenty members present.

This meeting was called to elect the officers for next term. For the office of Treasurer, H. Moser was proposed by R. M. Johnston and seconded by G. H. Wollaston, Esq. There was no other candidate and H. Moser was elected unanimously.

For the four members of the Committee, G. Dakyns was proposed by R. M. Johnston and seconded by H. C. Jones; J. Allen was proposed by M. O. Norris and seconded by G. H. Wollaston, Esq.; F. S. Cartwright was proposed by G. H. Wollaston, Esq., and seconded by H. P. Burt; R. A. Montgomery was proposed by G. H. Wollaston, Esq. and seconded by T. H Bailey; T. W. Stubbs was proposed by R. M. Johnston and seconded by M. O. Norris; C. H. Firth was proposed by G. Dakyns and seconded by E. A. Browne.

J. Allen, G. Dakyns, F. S. Cartwright, T. W. Stubbs, were elected Committee for next term.

A vote of thanks to the ex-treasurer, R. M. Johnston, on his leaving the school, was proposed by the President and seconded by the Vice-President.

The meeting then adjourned.

SUMMER TERM, 1874.

MEETING, May 21st, 1874.

The President in the Chair.

The first meeting for the term was held in the Physical Lecture Room. Seventeen members were present.

The President announced the result of the sale of the Transactions issued the previous term. He then exhibited fine specimens of Celestine, from a cleft in the mountain limestone of Durdham Down.

R. A. Montgomery then read a paper on a barrow which he had opened at Westbury-on-Trym, and other barrows in the neighbourhood of Bristol.

The President proposed that this Society subscribe £5 to the Sedgwick Memorial Fund. This was seconded by Stubbs, and carried unanimously.

Mr. Wollaston was then elected head of the Botanical Section, and the President head of the Geological Section.

THE TUMULUS OF WESTBURY.

This barrow, perhaps the most prominent one in the immediate neighbourhood of Bristol, is situated about a quarter of a mile beyond the village of Westbury-on-Trym. Ascending the hill where the Passage Road branches off to the left, a footway to Filton goes straight onwards, and, about the distance of 400 yards along this path, it passes within thirty feet of the barrow which is on the right-hand side. The tumulus consists of a large mound, standing in "Miltut Field" (which adjoins Mr. Green's shrubbery), and is perfectly circular, having a diameter of twenty yards, and an elevation of seven feet; it is overgrown with long grass, and set with twenty-three tall Scotch firs. In shape it comes under Sir Richard Colt Hoare's class of *broad* barrows. Seyer very briefly mentions it in his "Memoirs of Bristol," and also states that "in making a ditch in the same field, in 1815, many Roman coins were found, and a skeleton, having the knees gathered up to the head, which is considered the most ancient and barbarian mode of burial." These remains, however, can have no connection with the tumulus, but this appears to have been all that was ever written about it, for there is no account of its having been opened.

In December, 1873, I obtained leave to open it, and, with two men, commenced cutting a passage, four feet wide, from the south side to the centre. Here the opening was enlarged, extended to the east and west, and sunk below the level of the field. The barrow was found to be made of small loose stones of the neighbouring rock,—carboniferous limestone, and seems to have been unshaped, but used in their natural rough condition. Nevertheless, the barrow was very carefully built, the stones being piled up and embedded in a reddish earth. From the compact state of its structure, the mound appears never before to have been disturbed. During the course of digging, we exhumed many scattered bones of animals, some flint flakes, together with charcoal and ashes. Many empty snail-shells were found, at a depth of six feet, and they probably entered there to hibernate.

All these remains occurred at intervals, and were distributed over different parts of the barrow. Some of the bones are very interesting, and from them various inferences are deducible. They consist mostly of teeth, femora and other bones, in an advanced state of decay. Among others, we came across a very perfect tooth of a wolf, also teeth of the horse, hog, red deer, etc. Some of these *assa beluarum* appear to have been burnt, as they are blanched, while others retain their natural colour; and there thus appear to have been successive burials.

The number of flint flakes was small. Some of these are mere chips, struck off in shaping; but two of them are roughly worked *scrapers*, and bear evidence in favour of a high antiquity for the tumulus. They are quite white, owing to long exposure. No trace of pottery or metal was seen.

The charcoal was continually found in small pieces throughout the mound, but became thicker towards the centre, where a thin layer of it occurred with some calcined stones.

The internal construction of the barrow is not quite regular, as on its east side the stones are closely packed together, and extend from the top to the base, whilst on the west side the earth is more plentiful than the stones.

The excavation had been carried on some way in without meeting with any distinct signs of human remains. But when we reached the centre of the tumulus, we met with the most interesting relics we found. Under a heap of loose stones, on a level with the field, fragments of a human skull were discovered, belonging chiefly to the frontal and parietal regions. The largest piece is about two and a half inches square. They are blanched and fragile, and from their fractured condition, it appears that no care had been bestowed on their burial. The evident hurry with which this skull was buried is further proved from the fact that it was deposited in no chamber, cist, or any kind of coffin*, but merely laid on the ground, and stones thrown over it. I have not yet connected the pieces, to ascertain the dimensions of the skull: it is probably of early British type. Some of its parts and the jaws are missing; but detached human teeth, much decayed, though retaining some of their enamel, were found close by it, together with part of a human femur and some finger bones. Out of numerous other bones we exhumed, more human remains may occur, but those just mentioned are all I am yet certain of.

Canon Greenwell kindly gave me his opinion about this barrow, which he thinks is decidedly of British origin, and pre-Roman date. He says the mode of burial is a common one, and does not differ from a large number of tumuli in the north of England. He also thinks the human interment formed the central, or primary one, which supposition cannot be denied, for while most of the bones around it have undergone the process of cremation, these remains have been deposited unburnt. Their position alone would lead us to suppose that the mound was reared on their account. The individual must have been some one important, owing to the size of the barrow, probably a warrior, over whose grave this monument was erected, which, perhaps, marks the scene of his death. Its construction may have employed the greater part of some tribe, each individual of which was anxious to throw a stone on the funeral pile, as a tribute to the departed hero. The beasts were, perhaps, sacrificed on the occasion, which theory would account for their bones and the quantity of charcoal occurring in close proximity. The history of the tumulus can thus be slightly guessed at; but whether the field in which it stands was the scene of a battle, or why this spot was chosen for the dead, we are not likely to be ever informed. There may be other sepulchral deposits in the adjacent fields, but no external monuments or barrows mark the spots, and if there ever were such, they have long since been dispersed by the spade or the plough.

* No signs whatever of such constructions were met with.

There were no more meetings this term, the time of the members being otherwise occupied.

BRITISH MUSEUM
NATURAL HISTORY

Geological Map
OF THE ISLAND OF
UNST.
1°
55′
50′
45′
50′
45′
40′
Burra Firth
Scaw Bay
Norwick Bay
Haroldswick Bay
Balta I.
Balta Sound
Sandwich Bay
Blue Mull Sound
Skuda Sound
FETLAR
METAMORPHIC.
Serpentine.
Diallage.
Gneiss.
Micaceous Gneiss.
Mica & Talc Schist.
Limestone.
Chlorite Schist.
Var.° 22′ 35 W.
Miles

THIRD TERM, 1874.

MEETING, October 3rd, 1874.

The President in the Chair.

The first meeting for the term was held in Mr. Grenfell's room. There were Seventeen members and visitors present.

The President proposed G. H. Wollaston, Esq., as President. The motion was seconded by Montgomery and carried unanimously. G. Dakyns proposed, and H. Moser seconded a vote of thanks to the President, J. G. Grenfell, Esq., which was carried unanimously.

For the office of Treasurer, H. Moser was proposed by G. Dakyns, and seconded by J. G. Grenfell, Esq., and elected unanimously. In the office of Vice-President J. G. Grenfell, Esq. was proposed by G. H. Wollaston, Esq., and seconded by H. Moser, and elected unanimously.

For the members of Committee—H. P. Burt was proposed by M. O. Norris, and seconded by R. Anderson; G. Dakyns was proposed by H. Moser, and seconded by H. F. Fox; M. Heard was proposed by H. P. Burt, and seconded by G. H. Wollaston, Esq.; F. L. Cartwright was proposed by H. Moser, and seconded by W. Baillie; R. A. Montgomery was proposed by G. H. Wollaston, Esq., and seconded by H. P. Burt; T. W. Stubbs proposed by M. O. Norris, seconded by H. P. Beddoe. Of these G. Dakyns, H. P. Burt, M. Heard, and T. W. Stubbs were elected.

There are no minutes of the second meeting of this term.

MEETING, October 22nd, 1874.

The President in the Chair.

The third meeting of the term was held in the Physics School. Thirty members were present.

R. A. Montgomery read a paper upon the "Isle of Unst." After a few remarks on the paper by J. G. Grenfell, Esq., a vote of thanks to Montgomery was proposed by G. H. Wollaston, Esq., and carried unanimously.

The meeting then adjourned.

ON THE ISLE OF UNST.

It is owing to the remote situation of the Ultima Thule and to its quiet and sober population, that we seldom hear of it in daily conversation. Though, in summer, two large steamers and a sailing packet ply between Shetland and the mainland of Scotland, yet visitors are few. The wild aspect and wet atmosphere of these islands do not suit the tastes of many tourists. Yet Shetland is far from being uninteresting, both from a scientific and general point of view.

Unst, the island I shall attempt to give a short description of, is the most northerly of the Archipelago, and is one of the most

interesting of the group. It may be best, first, to give an outline of its natural features, and then to speak of the antiquities and local observations in the form of excursions through the island.

Physiography.—Unst is of oblong shape, eleven and a half miles long and five miles broad, and is hilly throughout, though none of its eminences can be called very high. Saxaford, though composed of mica schist, is the highest hill, reaching 938 feet. It stands on the northern extremity of the island, and is visible fourteen leagues out at sea. Vallafield Hill, with its serrated peaks of gneiss, runs parallel to the west coast, starting within a mile and a half of the southern shore and running up north as far as Woodwick, from whence its continuous chain is known under different names, such as Hevda Hill, Libber's Hill, and Hermaness. The island is divided down the middle into two nearly equal parts, by a long valley lying north and south, forming the basin of several lochs, the largest of which is the Loch of Cliff, or North Loch, long and narrow in shape, into which runs Balliaster Burn that connects it with Watley Loch, further south. Cliff Loch opens into Burra Fiord by Cliff Burn. Belmont Loch lies in the south-west. The hills of the eastern division are Vord Hill and Verdefield Hill, along the south-east coast, and to the north of Balta are the sharp peaks of Heyog and Crucifield Hill, standing at right angles to Vallafield. Along the north-eastern shore Keen Hill and Niov Hill are conspicuous. There are no rivers of any size in Unst, except the one mentioned as connecting the Lakes of Cliff and Watley. The latitude of Hermaness, the northermost point, is 60° 52′ N, but the detached rocks of Burrafirth lie farther out at sea. The most southerly part lies in latitude 60° 40′ N, and the first meridian passes close along the west of the island. Unst is separated from Yell Island by Blue Mull, or Blomel Sound, while the open Atlantic washes its northern and western shores. No very perceptible difference in temperature can be seen in the waters of either shore, that of Balta Sound, in September, being 53° F.

The predominating aspect of the western side of the island is that of peat bogs and heath, and the eye is struck by the total absence of trees, for Unst, and indeed most of Shetland, contains not a single tree, large or small, which is accounted for by the stormy winds that sweep over the land, diffusing the salt sea spray. The serpentine country to the east is bare and sterile, but herbage diminishes in poverty towards the south-east.

The whole coast displays fine examples of tidal action on various rocks; thus on the west, the hard gneiss, mutilated by the heavy surge of the Atlantic, is cut up into a number of narrow "voes;" and isolated rocks, called "holmes" and stacks, stand out in the sea, all probably once connected with the mainland and with the opposite Island of Yell. But here the waves are not so effective in their siege as on the northern coast, where the long inlet of Burra Fiord is formed in the mica schist. Again, on the eastern shore, the yielding nature of the serpentine rock is verified by the large encroachments

of the sea, as in the Bays of Norwick, Haroldswick, and Balta. The diallage is hard, good instances of which property are the Islands of Balta and Hunie.

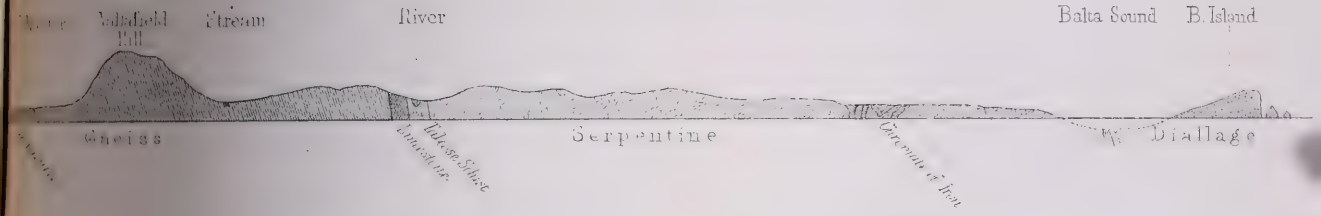
A few words may be said with regard to the form of hill peculiar to the different formations. The serpentine hills of Crucifield, Micaford, and Keen, have a smooth, round appearance, without any sharp and rugged peaks. This is due to denudation, weathering, and solubility. Heog's Hills, nevertheless, terminate in abrupt peaks, which I think is due to a hard intrusive rock running up through them. The diallage hills are somewhat broken, but the gneiss ridges on the

practice; and these are by no means solitary instances of the age of its inhabitants.

I was unable to ascertain the exact amount of rainfall, but it is considerable. A day, however, seldom continues rainy throughout, the showers being short and sudden.

Geology.—The rocks, now under our notice, may all be classed as metamorphic, and include gneiss, micaceous, talcose and chlorite schists, primitive crystalline limestone, serpentine and diallage, together with hypersthene, hornblende, slate, etc. The accompanying map shews the order of succession. There are many interesting topics here for the chemical geologist to discuss: as to whether the serpentine is a metamorphosed limestone, and the relation of such minerals as chromate of iron, amianthus, and asbestos, to their containing rocks.

The *Gneiss* occupies the entire length of the western side of the island, from Hermaness to Bellemont, and, as before mentioned, forms



Section across the Island, from Balta to Lollaster.

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The numerous brooks of Unst all run pure as crystal, owing to the rocky ground and the absence of mud; but on the western side of the island, the peat imparts to the small pools a black opaque colour. In some places I observed that the saturated turf, rendered elastic and air-tight by the exuberant moisture, was inflated by the air and water beneath into bubble-like swellings, which sink under the feet if walked on; if these tumid risings are pierced the water rushes out.

Climate.—The climate of Unst may be called wet and variable. Thunderstorms are not common, and little snow falls in winter,—the gulf stream keeping the summer and winter temperature from much variation; the mean annual temperature is only 2° lower than that of Edinburgh. The Aurora Borealis is sometimes seen here to great advantage.

Whatever may be the effects of a damp atmosphere on the human system, it undoubtedly promote healthiness, for the longevity of many of the inhabitants of Unst is remarkable. When I visited the island the Rev. Dr. Ingram was passing his 99th year, and the 71st of his ministry, retaining full intellectual vigour. The resident physician, Dr. Edmonston, though 84 years of age, still carried on active practice; and these are by no means solitary instances of the age of its inhabitants.

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The *Gneiss* occupies the entire length of the western side of the island, from Hermaness to Bellemont, and, as before mentioned, forms

a prominent row of hills. Its breadth varies from one to two miles, and its junction with the serpentine is well seen at the head of the small inlet on the south, near Belmont; in the north it unites with the mica slate of Saxaford and Burra Fiord. Its strata take a westerly dip, at an angle of nearly 45°, and the direction of its hills is parallel to its line of strike. It assumes the common form of gneiss, the felspar predominating, and the quartz often occurring in distinct veins. In some of the sections on the west shore it displays remarkable contortions and curvatures. In the neighbourhood of Woodwick and along the western side of Burra Fiord, it undergoes a striking change, which is, probably, only another stage of metamorphism.

Here, owing to its silvery aspect and fracture, it might almost be called mica schist, but the quantity of felspar it contains forbids the appellation. This micaceous gneiss differs from the other variety in its colour, which is reddish brown, and in its softer texture. It is interesting from the great number of garnets, or crystals of grenatite, scattered throughout it. These are most abundant at Woodwick. The crystals are dodecahedral in shape, and vary in size from a pin's head to half an inch in diameter. They are best seen on the weathered surface of the rock, for, being harder than the matrix, they stand out in relief. They occur again at the head of the Loch of Cliff, and along its north-western side. These garnets are opaque and red in colour. This micaceous rock is, probably, only a gradation between the true gneiss and the mica schist of Saxaford, but I have thought it better to indicate it by a different colour on the map. It is not found elsewhere in the island, and it extends from Woodwick up to and along the west coast of Burra Fiord. Two striking dykes can be seen in this fiord. They run parallel on opposite sides of the inlet, in a S.W. direction, both issuing from the Cliff of Saxaford. Another dyke is also seen near the head of Haroldswick Bay, and indications of intrusive masses in the peaks of Heog's Hill.

The *Serpentine*, in a horizontal section, shews the largest area, which is pear-shaped in outline. It is separated from the gneiss in the south by a thin strip of mica and talc slate, which becomes wider in the north. The eastern boundary of the serpentine is a line running N.E. and S.W., and at Gallow Hill this rock is only half a mile broad, but expands like a wedge towards Balta. Its external or weathered surface is of a brownish yellow colour, and the interior of a dark brown mottled with black. Masses are often found of an apple-green colour, which pass into "noble serpentine." This latter is of a fine green colour, semitranslucent, compact, and hard, and takes a good polish. The serpentine rock contains much magnesia, its softness and perhaps its solubility are due to this mineral, besides silex, alumina, and oxidulated iron. It forms a beautiful white sand, which seems noxious to animal life, for Balta Sound is comparatively destitute of marine fauna. The rock is also insalubrious to vegetation, as the bare and rocky hills indicate. The sea, as I have remarked, has made larger bays into the serpentine than in any other of the formations.

The serpentine contains the valuable chrome ironstone ($FeO\ Cr_2\ O_3$),

which runs throughout it in veins and pockets. This mineral has a crystalline appearance; the mineral map shews the area over which it extends. The ore is divided into three qualities, according to the amount of serpentine with which each is mixed. The first quality, now all but exhausted, is visibly free from the containing rock, and is of a coal-black colour, opaque, and very heavy, and has a submetallic lustre. It is subject to disintegration, is brittle, and its fracture is uneven. The second quality has a mottled look, while the third consists merely of specks of ore, disseminated throughout the serpentine, resembling grains of gunpowder. The chrome ironstone, which has proved highly remunerative to the proprietors, was discovered by Dr. Hibbert, in 1817, but it was not worked till 1822. It first fetched the price of £10 per ton, but soon fell, as ore of a better quality can be obtained from Russia and America; however, manufacturers find it convenient to mix the two. It is used for producing yellow and green pigments, and the colours magenta and solferino, in oil, porcelain, and water-colour painting. Part of its protoxide of iron is replaced by magnesia (derived from the serpentine), and part of the oxide of chromium by alumina. Alone, it is infusible before the blowpipe flame, and it fuses with difficulty in borax; but the emerald green colour of oxide of chromium becomes very apparent when the bead is heated in the inner flame.

The few quarries for this ore are now no longer worked. They are situated chiefly at Swinaness, Haroldswick, and Balta (Burness House). A little of it is also said to occur in the Island of Fetlar.

At the point called Swenee Ness, north of Balta, that rare mineral, native hydrate of magnesia, or Brucite (MgH), was discovered by Dr. Hibbert, many years ago, former mineralogists believing it to be a white talc. It occurs in thin veins through the serpentine, in aggregated, foliated plates, of silvery white colour; it is translucent when newly fractured, but, on exposure to the air, it absorbs carbonic acid and becomes white. Its composition shews a large percentage of water,—

Magnesia	68.97
Water	31.03
	100.00

An analysis of it, by Thomson, has the following result,—

Magnesia	66.67
Protoxide of Manganese .	1.57
Protoxide of Iron . .	1.18
Lime	0.19
Water	30.39
	100.00

Swenee Ness is the only British locality for this mineral, and even here it is now very scarce, and an impure kind only is to be procured, which is mostly composed of carbonate of lime. I will mention the other minerals of Unst hereafter.

The *Mica Schist* runs in a thin band northwards, where it expands into a large surface, on which the Hill of Saxaford stands. It is of a greenish colour, but often becomes dark and talcose, and is intersected by quartz veins. It thus differs from the micaceous gneiss of Woodwick, which is brown.

The projecting points of land, known as Lambaness and Skaw, are composed of gneiss, and stand out against the sea.

The Loch of Cliff, or North Lake, is geologically interesting as lying on a very pure crystalline *limestone*. This rock is best seen on its eastern side, where it has been quarried for calcination. On the other side of the lake it cannot be seen. It is traced in a narrow band as far as Coldbacks, where it disappears. It used also to be quarried for lime on the south of Baliasta. Its strata are very distinct, dipping eastward, at an angle varying from 60° to 70°. The line of strike is in a N.N.E. and S.S.W. direction. No traces of fossils have yet been discovered in it; its stratigraphical age is therefore only conjectured. It contains much carbonate of lime, in the form of white streaks. The section across seems to confirm the theory that the serpentine is, possibly, metamorphosed limestone. At the northern end of Cliff Loch, quartz rock is found in abundance.

The *Diallage* rock, or *Euphotide*, lies in contact with the eastern side of the serpentine, and, near the junction, appears to cross it in abrupt masses, but no decided gradation between the two rocks can be recognized, the junction being always distinct. The rugged form of Balta Island best illustrates its external aspects, for it is slowly acted on by the atmosphere, owing to its natural hardness and compact structure. In colour the diallage varies from light green to black, and weathers grey. As before noticed, it yields a comparatively good herbage. It contains amianthus and asbestos.

The *Chlorite Schist* occupies the south-east corner of the island, and unites with the diallage near Uya. It is of dark green colour, and is intersected by numerous quartz veins. At its eastern extremity, patches of the serpentine and diallage again crop out.

I believe the Island of Uya also to be composed of this schist, but I had not an opportunity of visiting it.

There are no distinct signs of glaciation in this island, boulders being absent, and no glacial clay occurring round the shores. I must not, however, omit mentioning a large rounded stone which lies on the surface of the ground, by the road side near Uya.

Minerals.—Unst is of great mineralogical celebrity. Most of its minerals are rare, and two of them are peculiar to itself in the list of British minerals.

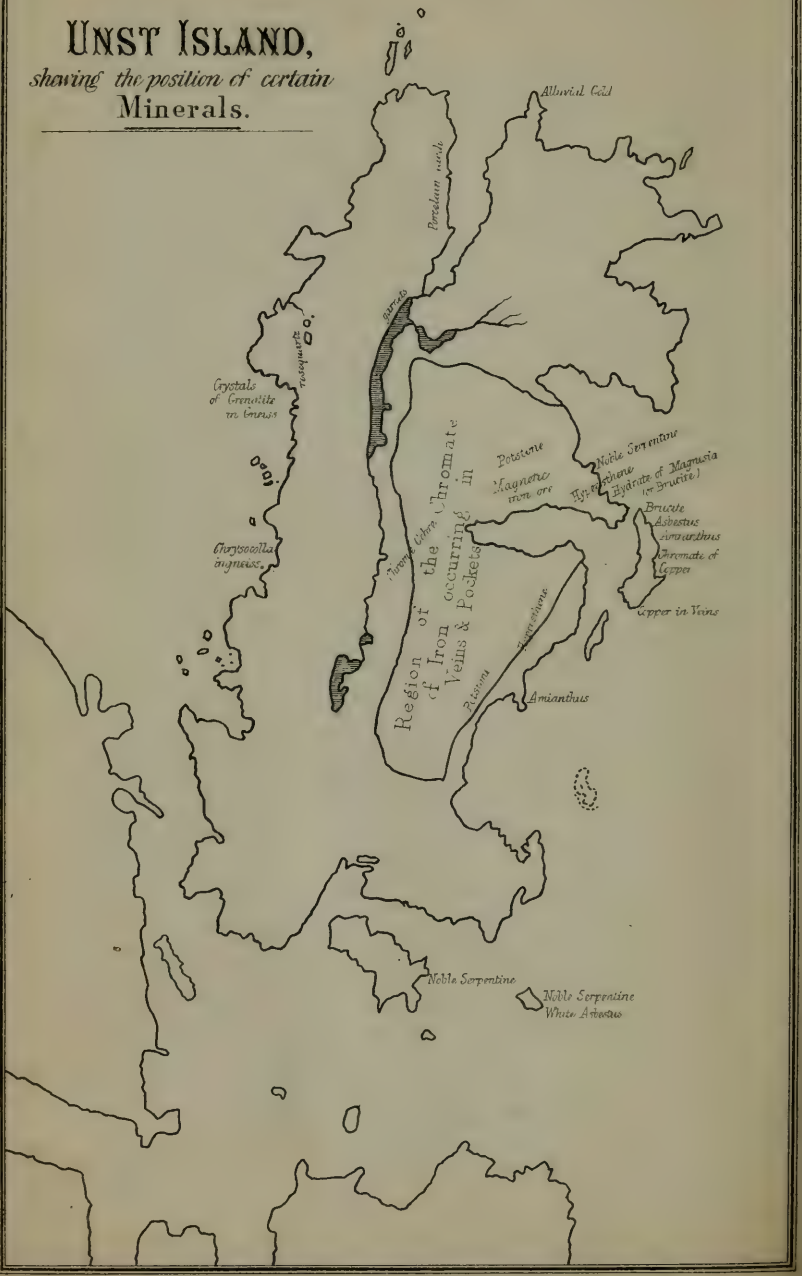
The most important in value is the above-mentioned *chromate of iron*, though its mines seem almost exhausted, and its actual extent is still a point of discussion.

Perhaps the *hydrate of magnesia* should rank next in value as a museum mineral, and for use in the arts, the *chrome ochre* of Unst must be next considered. This is found around Balta as a clayey substance, occurring in a pulverulent state, in loose earthy masses, of a

UNST ISLAND,

shewing the position of certain

Minerals.



bright bluish green colour. It is opaque in appearance. Its specific gravity is 2·7, and its composition is thus shown, $(\ddot{A}l, \ddot{C}r, \ddot{F}e,)\ \dot{S}i_2 + 6\dot{H}$, (*Hausmann and Nicol*). It occurs nearly pure in small fissures in the chrome ironstone, and is infusible by itself, but, on subjection to the blow-pipe flame, becomes paler. With borax, it forms an emerald green globule.

This interesting substance, though purer, does not probably much differ in composition from the chrome ochre of Silesia, which is thus analysed by Zellner,—

Silica	58.50
Oxide of Chromium . .	2.00
Alumina	30.00
Peroxide of Iron . . .	3.00
Water	6.24
	99.75

This mineral is sparingly scattered around the Free Church and in the neighbourhood of Balta, and does not occur elsewhere in the island.

Asbestos is found abundantly on the serpentine of Swina Ness and Keen Hill, and on the diallage to the south of Balta. Also on Balta Island. This hornblendic substance, a variety of actinolite and amianthus, is used for lampwicks and for making fireproof safes, owing to its long, fibrous, flexible, and incombustible texture. It can be woven into fire-proof cloth. It is white in colour.

Amianthus. The locality for this is on the eastern side of Balta Island, and all over Keen Hill. It is a pure variety of asbestos, but much heavier, compacter, and not so flexible as the latter mineral. It is of a fine, bright green colour, shiny, and its fibres are not easily separated, as they are very brittle.

Noble Serpentine is of course found in the serpentine district round Balta. The best spots for it are near Keen Hill and Swina Ness, and on the shores of the Sound. It is said to be found also in the islet of Naaf Gruna.

The *Garnets* I have already mentioned as being profusely scattered through the micaceous gneiss of Woodwick.

At this place I also obtained specimens of *rose quartz* which had garnets embedded in it.

Along the west coast, in the 'voes,' there occurs in the quartz veins of the gneiss an emerald green substance, which I believe to be *chrysocolla.*

Balta Island is interesting to the mineralogist, as it contains besides the aforesaid minerals, green veins of copper ore with *chromate of copper* in small quantities, which latter is of a bright green hue, and powdery. Traces of Brucite have been observed at the northern extremity of this island.

Fine specimens of *hypersthene* are found on Keen Hill and south of Balta. One variety has a grey, metallic lustre, and considerable

weight; the other is greenish black, with a lamellar structure, and is translucent in thin sections, with a green tinge. The surface of its fracture is resinous. It is found about Balta.

Potstone is found all around Balta; and *Porcelain earth* or *Kaolin*, is found on the western side of Burra Fiord, and occurs on the south west Fetlar Island. This mineral is earthy, opaque, and dull, and very friable. It is probably derived from the decomposition of the gneiss.

Alluvial Gold is said to have been discovered on a point of coast to the east of Burra Fiord and there is good authentic evidence of its occurrence here. On the shores of this fiord, I found some fine varieties of granite. They were fragments of large waterworn pebbles, drifted here from some foreign country, and contained large plates of pure mica. Besides these, eurite and various porphyries are found.

Magnetic and *Bog Iron* ore are found abundantly on Keen Hill, and a dark ore, which I believe to be *Hausmannite*. I also found purple crystals, probably of some manganic compound, but not having seen their analysis, this is only conjectural.

Botany.—The flora of Unst, as we might expect, is of a boreal character; its flowers are hardy and grow mostly in the rocky ground, and though they are few in number yet they are interesting. The first list of the plants of Unst was made by Thomas Edmonstone, who discovered in his native island the *Arenaria Norvegica*, a flower hitherto unknown to the British flora. The only spot in Great Britain for this rare plant, is a bare and rocky piece of ground, at the south-western foot of Keen Hill, on the northern side of Balta Sound. It grows among the small and loose stones of serpentine, (it cannot be called soil,) where even the grass will not thrive. It does not exceed three inches in height, but has long roots. A species of Arenaria, which is supposed to be the same as this flower, grows on a cliff at Ben Bulben, in Sligo, Ireland; but the Shetland variety is distinguished by broader sepals and more succulent leaves. Its seeds, probably, came here from Norway, and, thriving in the rock and sea air, the plant has since continued to grow, but even in this locality it is by no means abundant.

A species of *Lychnis* grows in a 'chromate quarry' to the south of Balta, and the sea pink on Heog's Hills. The *Linnea Borealis* is common all over the Island and grows chiefly on peaty ground. Various sandworts are found on the beach in some of the sheltered bays. Many other flowers occur, but of their names I am yet ignorant.

During my stay in Unst, I saw not a single butterfly, and the *lepidoptera* are no doubt absent; but the list of *coleoptera* is much longer, and I counted several genera: the serpentine hills are the haunts of a small red beetle, and the standing pools of water contain many water-beetles.

Marine zoology may be studied with advantage in Unst at certain seasons. Balta Sound is the most convenient for dredging in. Its

bottom is of white shelly sand, and its depth, nearly opposite the centre of Balta Island, is eight fathoms, which diminishes towards the head of the bay down to two. The few hauls of the dredge which I had in Unst were not very productive. The *fusus* is among the chief of the mollusca, and small *cephalopods* occur. But there is a great difference in marine life between this Sound and that of Bressay, on the mainland of Shetland; no *holothuridæ*, no brittle stars, *ophiuras*, *solasters*, or *goniasters*, are here found, which swarm in Lerwick harbour.

Where the deep sea fishing is carried on, in the months of May and June, is a fine place for marine specimens. Off the east coast of Shetland, in 80 fathoms of water, the purple echinus (*Spatangus purpureous*) is found; also the *Brissiopsis lyrifera*, and the remarkable 'Pipa' echinus (*Cidaris papillata*).

Sponges are to be obtained on the shore only after the storms of winter.

Unst affords good sport to the angler. Cliff Lock, near Baliasta, is 3 miles long by a quarter of a mile broad. As before remarked, the Burn of Baliasta flows into it at the southern end, and Cliff Burn, its outlet falls into Burra Fiord, which yields splendid sea-trout. There are private boats on the Lake, but the fishing is quite free. Balta, though containing no Inn, is the only place to procure lodgings at near the lake. June and July are the best months for fishing it. The trout run 3 to 4lb, and are numerous; 33lbs being known to have been caught in a few hours. Watley Loch, lying three miles further south, and connected by Baliasta Burn, is a mile long, and open to the public. It contains small trout, but plenty of them. Belmont Loch, two miles south-west of Watley, is half a mile long, and its fishing belongs to Major Cameron. Trout run about 3lbs. each. There are many other small Locks in Unst.

ANTIQUITIES AND SCENERY. There are very few islands that can compete with Unst in abundance and variety of ancient remains, found in a small space. It is the first place the Norsemen landed at when they came to people Shetland; and when Harold Harfager came to wrest it from these pirates, he is said to have landed at the bay that still bears his name; and, on the shore of Haroldswick, there are the remains of a cairn, or tumulus, which tradition points out as his grave. But Unst appears to have been of importance in Pictish times, long before the arrival of the Norsemen. Besides the more lasting relics the early inhabitants have left, we find their domestic and warlike implements. Many *celts*, or stone axe-heads have been picked up in this island, and in the Antiquarian Museum of Edinburgh are deposited no less than twenty-five worked stones from this locality. Nine of them are polished and chipped celts of sandstone and serpentine, etc. These vary in size from $2\frac{1}{2} \times 4\frac{1}{2}$ inches, to $3\frac{1}{2} \times 1\frac{1}{2}$ inches. The rest are club-shaped stones, sinkers for fishing nets, hammer stones, ladles, oblong-shaped instruments, tureen-shaped vessels and rubbing stones; also the fragment of a sculptured stone,

found in the island of Uya, forming the cover to an urn of steatite, containing burnt bones. In the British Museum are some roughly worked stones from Unst, and seven vessels of chlorite schist, found in a kistvaen, by Dr. James Hunt. (Anthr. Soc : vol. I.)

The only two places that the visitor to Unst can put up at are Balta and Uya, of which the former is the best and most interesting, as it is in the centre of the island, and, therefore, the minerals, chromate of iron and hydrate of magnesia, the Arenaria norvegica, and the circles on Crucifield, are all easily reached. So, from Balta, whether the tourist mounts the hardy shelty, or prefers exercising his own legs, he may survey the whole island in about four excursions.

I shall now attempt to give a short description of the various objects of interest as I passed them in an excursion to the southern part of the island. Starting from Balta, and steering straight over Verdefield Hill, the boundary between the diallage and serpentine is passed, but on either formation about here, the country is uninhabited, and the coast uninteresting. The sea is shallow between here and the opposite island of Hunie, and a whale is reported once to have grounded on the intervening sandbank. These are not rare visitants, and at Buness House, Balta, the ribs of a large whale, caught here, are deposited. Continuing south, the point of Orough is reached. Here the ruined homesteads of Colvidale indicate the decrease of the population. There is here a square inclosure, still used as a place of burial, which contains the last remains of an old kirk. This building, which now serves as a shelter for cattle, is of oblong shape, enclosed by four walls, which reach the height of seven feet in their highest part, and are built of loose stones without any mortar. The chapel is only four yards broad, and fifteen yards long. The door was on the west side, but no signs of windows are visible. After the church was abandoned, it appears to have been selected as a place for the dead, as there are tombstones inside, one being a flat one resting on four supports, the inscription illegible. Human bones lie scattered about, and the ground inside is overgrown with weeds. On the coast here is the small open bay of Sandwick, with Vord Hill on the right hand. Before reaching the village of Muness, a small burn is crossed, which runs through the vale of Hannigarth, formerly connected with Shetland superstitions, as a place frequented by ghosts and fairies. The chlorite schist now takes the place of the diallage. The old feudal castle of Muness is the next object of interest, but nothing is done for its preservation, it being left open, and frequently serving as a cattle-shed. It is of oblong shape, its solid walls having a thickness of four feet, and built of stones quarried on the spot, though the ornamented parts are of hard freestone. There are large circular towers at its north-western and south-eastern corners, while at the other angles there are small hanging turrets, with beautifully sculptured machicoles. It has oblong windows at each side, besides several loop-holes, some of which display peculiarities from their quatrefoil and starlike shapes. The castle has two storeys, the upper one is divided into three rooms, the two end ones connected with the towers, and the

central one, which is the largest, has a wide arched fireplace. This storey has neither roof nor floors. The lower part of the building is divided into several small rooms, without any apertures for light, and were, probably, provision store-rooms. They all open into one narrow passage on the southern side. At the basement of the towers are two vaulted cells, or dungeons. The castle's entrance-door is in the southern wall, and over it is carved a coat of arms, and the following quaint inscription, beautifully raised in gothic letters, which serves to elucidate its age and history.

List ze to know this building quha began?
Laurence the Bruce, he was that worthy man;
Quha earnestlie his airis and offspring prayis,
To help and not to hurt this wark alwayis.

THE ZEIR OF GOD. 1598.

This Laurence was himself the author of these complimentary lines, but his recorded deeds prove him to have been no "worthy man."

I now struck west for Uya, proceeding along the southern coast, over the barren ground. Here, on an eminence, half a mile before reaching Uya church, there stands a huge pillar of stone, commemorative, no doubt, of some great event in the days when the island was convulsed with feudal warfare – perhaps the scene of some decisive battle, or it may define a boundary of ancient territory; or, shall we rather say, it marks the last resting-place of some hero who played a prominent part in his day. Conjecture must always take the place of history in accounting for the erection of such monuments, for their origin is enveloped in mystery and tradition: but the traces of a people, long since fallen to decay, is sufficient in itself to awaken human interest and curiosity; but all investigation must result in bare opinion. I measured the height of this stone as ten feet two inches, and its diameter at the base as three feet. It is composed of chlorite schist, the rock on which it stands, and it can be seen from afar. It is known by the villagers as the "Stone of Claverhouse," and is, of course, associated with their superstitious tales. It has evidently undergone very rough shaping, but no one knows with what tools. The village Uya contains several cottages and a shop or two. Here there is also a harbour and pier; and in the sound, formed by the opposite island of Uya, is one of the anchorages of the steamboat, "Chieftain's Bride," which plies weekly between Lerwick and Balta. The herring fishery also is carried on in summer and autumn. Uya island is a mile and a half long, and contains good pasture ground. It is inhabited by the proprietor. About sixty years ago a barrow was here opened, and interesting urns are reported to have been found. Leaving the diallage, the serpentine eminence of Gallow Hill is next reached; its name tells us that it was an ancient place of execution, and this has been further determined by the discovery of human bones on the summit, where there is a heap of loose stones, probably the remains of a rifled cairn. The view from the top of this hill is extensive

and varied; it commands the whole of the fertile island of Uya, while, further back, the cliffs of Fetlar rise boldly from the sea, and the green patches of land in the blue water look very picturesque. The coast along here seems to have been of great importance in ancient days, for it was guarded by several circular *burghs*, or (broghs) small fortresses. The remains of four of these old fortifications are very distinct. They are, probably, of pre-Scandinavian date, but their age bas not been ascertained. They are supposed, however, to be of Pictish origin. The first of these burghs is situated on a point of land to the west of Gallow Hill. Its interior is defended by two semi-circular ramparts of earth, the inner one five yards, and the outer ten in breadth, with an intervening ditch. At this same point the serpentine and diallage rocks unite. Bellemont House, the seat of Major Cameron, a large proprietor of land, next demands attention, and here the gneiss is reached. Another burgh is traced on a point south-west of Bellemont, the dimensions of which are much the same as those of the last one. Proceeding northwards, I passed some small lakes, and near one of these, in the hamlet of Snaburgh, there is another specimen of a burgh. Its present external aspect is a heap of stones and earth, but within a space is seen to be enclosed by a wall, the foundations of which alone remain, thick enough to contain hollow apartments. The northern side of the tower is defended by earthen ramparts with wet and dry ditches, and the southern side by the lake. Years ago a plan of this fort was made by a Mr. Low.

The coast along here, on the west, is broken by many creeks and *voes*, and the sections of gneiss displayed exhibit great contortions and curvatures. The sides of these inlets are very steep, but the hardy Shetlander climbs down the bare rock with great agility, to fish among the *sillocks*. I now ascended the lofty headland of the Moul, and was repaid by the view. To the west lay the barren island of Yell, with its smoking kelp fires, separated by the foaming Sound of Biomel, whose waters, owing to cross currents, carry on perpetual tumult. To the north-east, in the far distance, Saxaford reared itself, looking like a "pillar of heaven," for its summit was lost in the clouds; while nearer, the wild hill of Vallafield stretched northwards. The foundations of ancient huts and boundary stones, are seen on the Moul. Here there is nearly always a strong wind blowing. To the north of this prominence lies the open bay of Wick, affording a good landing-place, but no harbour. On its beach a species of sandwort grows. Wick was once a thriving village, but now the many ruined cottages tell another tale, their tenants having since emigrated. The standing walls of a small ruinous kirk heighten the scene of desolation; its interior is used as a burial ground, and many sea-birds take refuge in it, screaming to the dismal chant of the waves. All these adandoned chapels are of simple architecture, of mere oblong-shape, and now roofless. Their numbers shew the decay of a religious population of Roman Catholics. At the opposite side of Wick Bay, the gneiss is again much curved. The summit of an

eminence, at the head of this inlet, is formed into a very perfect fortified burgh. No more of these appear further north, but a fine specimen is said to occur on one of the *Holmes*, or rocks, lying of Wick. The fort in question is of much the same size as those already passed, and consists of an inner circular chamber, ten yards in diameter, whose wall is several feet thick, and, no doubt, contained rooms like those at Snaburgh. An oblong ditch lined with stones, two feet deep and two broad, lies across this court in the direction of east and west, but what was its purpose I cannot say. Two ramparts of earth defend this fort; the outer one is ten feet high and about twenty broad at the base, and surrounds the keep except at the western side, where it is not needed owing to the steep declivity of the hill. The inner one is of the same height, and forms a complete circle. A ditch is dug between these ramparts, and another one outside, which latter, probably, served as a moat.

Such forts were, no doubt, originally circular towers with surrounding earthworks and ditches, similar to the well-known burgh of Mousa, on the west coast of Shetland. Their walls, of which only the foundations now remain, were thick enough to contain small rooms, while the inner space served to store provisions in. The hill of Vallafield has here its abrupt southern termination.

I now proceeded inland towards the east, to take the road that leads from Uya to Balta. When about three quarters of a mile inland (E.S.E. of Wick), attention is attracted by an enormous stone, standing majestically on the wild heath, like a sentinel whose hoary locks of lichen tell that it has stood throughout ages, and, though now slightly leaning, it looks as though it would stand for many more. This gigantic monolith is of much larger size than the one at Uya, and its date and cause of erection are likewise mere matters of conjecture. It is composed of gneiss, and was therefore brought from no distance. I measured it as over fourteen feet high, eight and a half broad, five feet thick, and twenty-one feet eight inches in girth, and it must have nearly a third of its entire length below the surface of the ground; it is quite unshaped. What grand occasion could have employed so many hands in the setting up of such a monument? Perhaps some signal victory, or the triumph of some chief, for no doubt these early tribes had their heroes. Perhaps, then, to the memory of some Wellington or Nelson of a former day, was erected, not a mortared column, but one huge stone set on end, that would defy the ravages of time and transmit to future generations the fame of ancient deeds. We know nothing about these stones—there is no inscription, not a mark to guide us; they may be of any age, and we should, probably, arrive somewhere near the true date of their erection, if we assigned them to a time far before the days of the Vikings.

A few more steps over the solitary heath brought me on to the safe road to Balta. Near Watley Loch, before the road crosses a small wooden bridge, there runs a brook called Yelaburn, whose waters were, up to recent times, supposed to possess sanitive properties. The custom was that all who imbibed its waters were first to throw in three

small stones, and a considerable pile of these offerings may be seen a few yards to the left of the road. But modern profanity, which laughs at such superstitions, has ceased to invoke the favours of the water sprite; and everywhere we find superstitious ideas giving way to true argument. Another two miles northwards and the peaceful shores of Balta are reached.

All the walls of Unst are built dry, and so we often find old foundations and lines of stones, which must not be mistaken for relics of antiquity. Barrows are not common in Unst, and they take the form of the cairn or piles of loose stones.

It is worth spending a day close round Balta, for many interesting objects are situated in the middle of the island. The most prominent of these are the concentric circles on Crucifield Hill, which receives its name from them. As they cannot be seen at any distance, owing to the rugged nature of the serpentine, the best way of finding them is to steer E.N.E. of the ruinous kirk of Baliasta (situated to the south of North Lake), until the top of Crucifield is reached. These circles are of a type very rare in Britain, for they are not defined by stones standing apart from one another, neither by low blocks, but they consist of perfectly circular mounds, composed of large and small stones embedded in earth, and enclosing a space in which are similar circles having a common centre with the outer circumference. There are two sets of these constructions on Crucifield Hill. The larger contains three such circles—the diameter of the outer one measures fifty-six feet, and the mound is four feet thick at the base; the middle ring is forty-six feet in extreme diameter, and five feet thick, and is separated from the outer by a shallow ditch; while the innermost circle is thirty-four feet in diameter, and four feet broad. In the middle there is an earthen pile, fourteen feet wide, and one foot high. The highest part of these mounds is twenty inches, and the largest stone I could see among them is four feet long, two broad, and one thick, and composed of serpentine; some of the stones are of diallage.

Thirty-six feet south-west of this "temple" is another consisting of two concentric circles, with a low tumulus in the middle.

One of the circles contains three small erect stones, the highest being two feet three inches, and these seem to shew that the mounds were once higher, though even now their circumference is perfectly smooth and undisturbed. Of this group of circles the outer one measures thirty-one feet in diameter, the inner eighteen feet, and the central pile nine feet.

Opinions seem to differ with regard to the purpose of these constructions, but it is generally agreed that they are of Scandinavian origin, for similar remains are found in Norway. Some suppose them to have been civil courts of justice, where the floude, or judge, occupied the interior circle, while the assembly arranged themselves according to rank in the outer circles. Others connect them with the religion of the Norsemen, as places where sacrifices were offered to Thor and Odin, and other Scandinavian deities, and this seems to be the most probable theory. If these then, are the temples where the

ceremonies of religion were performed, the pile in the middle of these circles must have originally been altars, whereon human sacrifices to Odin and Thor were offered. The victim, we are told, was laid on the stones, and his life extinguished by crushing the spine. The priest officiated in the inner boundaries while the people assembled round the outer ring. How different is the scene now! The thunder-cloud still passes over the spot, and the altar, washed by the rain of centuries and long ago deserted, is now trodden under the hoofs of the shelty. Close by is Heog's Hill, which is interpreted to have been a place of execution, *Hanger Heog* signifying a "heap of stones," and on its summit, Dr. James Hunt, of the Anthropological Society of London, in 1865, exhumed a quantity of human bones, besides roughly worked stones. Dr. Hibbert who searched into its history, says that "if any accused person, after hearing the sentence of the layman, was desirous to appeal to the voice of the people, he tried to effect his escape in a direction that led to the more westerly circle of stones, situated on the adjoining hill; and if he reached in safety that sacred site of ground, his life was preserved, but if the popular indignation was against him he was pursued on his way to the sanctuary, and anyone, before he reached it, might put him to death."

One hundred and thirty yards to the north of the large circle, may be seen the remains of a fine sepulchral cairn, or tumulus of stones. It has been much disturbed, but I should say its original diameter was about ten yards, and the rough pieces of serpentine of which it is made must have reached the height of several feet. In its centre there is an oblong cist, or kistvaen, made of flat stone slabs set on end, and it is divided into two cells by another stone laid across the middle. The lid of the cist is gone, and it has been rifled of its relics. The above-mentioned seven vessels of chlorite schist, in the British Museum, were taken from a kistvaen in Unst, and I conclude they came from this one. The length of the cist is in a E.N.E. and W.S.W. direction, and the western division measures three feet nine inches long, and three feet broad; the other half is four feet long and three feet four inches wide. Its depth is two feet six inches, the bottom not being paved with stone.

Twenty yards south of this cairn are the traces of another one, opened in all probability at the same time.

Baliasta is a sheltered hamlet north-west of Balta, and contains a ruinous church, of the same style of architecture as the others I have alluded to. Near it, Dr. Hibbert, writing in 1817, has recorded the existence of concentric circles; but no signs of these can now be seen, having since been obliterated. They are said to be of larger diameter than those on Crucifield, but displayed the same construction. "They are formed" says Hibbert "by three concentric circles, cut into the stratum of soil that covers the serpentine, into which boulder stones or earth were thrown, until they rose above the level of the ground. The diameter of the outermost circle is sixty-seven feet, of the middle one fifty-four and three-quarters feet, and of the innermost forty feet.

There is a small central tumulus of stones in the middle of the enclosure, twelve feet in diameter, the presence of which is no unfrequent indication of a Scandinavian temple."

But in a field close by are some stones standing in a circular direction, the highest being three feet, and three and a half feet broad. They are surrounded by other large stones, most of which are prostrate, and in the centre of all is a mound of stones. These remains, however, bear no resemblance to the concentric circles. There is another small standing stone, half a mile south of Baliasta, three feet high and unshaped. Around here and Balta are many foundations of walls, built and demolished in modern times.

The mineralogist should here examine Swenee Ness and Keen Hill, both situated to the north of Balta, and which furnish most of the minerals I have before enumerated. Balta Island is also worthy of a visit. It is only a mile and a quarter long, but contains many remains of a bygone age, besides being rich in minerals. Its highest point is at its southern extremity, and here it is half a mile broad, but in one part its breadth diminishes to only a few yards. It is entirely composed of diallage, and on the eastern shore it is high and precipitous, and displays some magnificent rock scenery; the many isolated rocks and holms shew its former extent, while the long and narrow voes, running into the land, offer a fine instance of the wasting action of a stormy sea. The surge runs up them with great violence, and in winter often washes over the island to a height of many feet, drifting large rock fragments up the steep inclines. One of these masses, which stands at the head of a narrow passage forced through the rock, measures fully four feet by two and a half: the height it was raised is about 25 feet.

The western, or inner side of the island, takes a gradual slope to the sea, and has a narrow beach of white sand.

The turf at the top is furrowed by many rabbit holes, and is strewed with the shelly remains of crabs, fished out by sea birds, and carried on land to devour. Fine specimens of *actinozoa* and *berões* may be obtained in the sheltered pools along the coast. The "North Channel," which separates the island, is a rapid tideway, flowing over a shallow rocky ground, and forbids all but rowing boats to enter Balta Sound from the north. In walking over this islet, the foundations of old walls are passed, which mostly run across from east to west. Near the centre of the island is the ruin of what appears to have been an old burgh, of oblong shape, built of double walls. The enclosure inside measures fifteen feet long and six broad. Each wall is about four feet thick, and stands three feet high, and the distance between the outer and inner walls is three feet. Other ranges of circular stones are seen, and near a small bay towards the southern end there stands a cairn of stones, apparently undisturbed, and its eastern side is joined to a circular enclosure of loose stones.

On the hill at the southern extremity there are the foundations of many small enclosures, which appear to have been huts for public security, of the same kind as those at Wick. They are elliptic and oblong in shape, and only nine feet in length. I counted at least a

dozen of them ; they seem to bear no relation to each other in position. I was told that human bones have been found on this island.

Having done with the central parts of Unst, the coast line of the northern half alone remains to be visited. Leaving Balta to the west and crossing the river that waters a fertile valley, the dreary hill of Vallafield is ascended. As before noticed, this is a ridge of gneiss, covered with peat bogs, which, though very valuable to the inhabitants, have a cold and bleak appearance.

The western side of this hill is abrupt and precipitous, and in the section looks like an escarpment. At its foot lies the plain of Collaster, which, in spite of its close proximity to the sea, is a beautifully-green grass plot. Collaster is rather the name of a place than of a village, but it contains three small cottages, and a veritable Shetland water mill. Of these primitive constructions several remain throughout the island, but as they are all built alike, the description of one will suffice for all. It consists of a few large loose stones laid on one another, uncemented by mud or mortar, till an oblong hut is formed, on which a roof of turf is laid, the whole erection being no higher than an ordinary man's shoulder, and about eleven feet long. The door is only four feet high. Part of the floor is smooth, on which the flour is collected. The axle of the wheel is vertical and therefore the stream runs directly under the mill, through a narrow gutter, and in its passage forces round a small paddle, for it can hardly be called a wheel. The lower millstone is fixed, and the upper one connected with the axle. The grain is heaped in a deep square trough, and is let out by an aperture, which hangs over the centre of the millstones ; to keep the grain steadily running, the trough is made to rub against the moving stone, and by this means the corn is shaken out at a constant rate. A means is also provided for grinding coarse or fine meal ; the axle of the millstone rests below the paddle on a horizontal beam, which, by raising or lowering, alters the space between the grinding surfaces.

A little south of Collaster lies the village of Newgord, overlooking Wick Bay. Here, on a slope facing the sea, are the remains of some ancient buildings, probably of the time when the Scandinavians held the island. They might have been separate huts, but appear rather to have been a square enclosure, divided into small oblong compartments. These remains consist of straight lines of large stones, some erect and some prostrate. There are two distinct groups or squares of these ; the first and most northerly contains sixteen stones, and encloses an area of forty-five feet square. In one corner, a large slab of gneiss forms the side of a small square cell, and this stone appears to have been shaped, and stands erect five feet, is six long, and two feet thick. The others that stand at right angles to it are about half its size. The rest of the stones that form this enclosure are prostrate blocks, but some of large size. The second group lies a few feet off, and forms another square of smaller size but more compact. It contains eight stones, the highest being three feet nine inches, and the longest is four feet six inches : these are not shaped. In another

part of the same field is a straight line of small blocks, taking a seaward direction. What was the purpose of this building it is hard to say, probably they were dwelling houses and not fortifications.

Having again come upon Wick Bay and the Moul headland, I turned back northwards, keeping between the precipitous flank of Vallafield and the rugged shore. The coast line all along here is a perpendicular cliff, eaten into many romantic little "voes" or creeks, and wherever a bit of beach is exposed it consists of large water-worn pebbles. Fine sections of curved and straight bedded gneiss are seen, its felspar containing green stains of a mineral resembling chrysocolla, but whether this is so I have not perfectly ascertained. Further north the brown heather again takes the place of the grass. Vallafield here attains the height of 697 feet. Passing the *holms* or insulated *stacks* of Woodwick, we reach the inlet of that name. Here there are some abandoned fishing booths, and the garnets beforementioned are found thickly dispersed through the rock, while specimens of rose quartz lie scattered about. The sea has at this spot worked some way up a deep and narrow valley which runs towards Balta. This lonely vale, the refuge of the raven and other birds, is separated from the sea by Hevda Hill; a small dark coloured stream gurgles through its peaty soil in which the *Linnea Borealis* grows abundantly. Round masses of gneiss close this valley in to the north. A peculiar air of solitude reigns about this desolate shore—the monotony of the wind and waves, the traces of former inhabitants, and the ruins of the deserted chapel mounted on the brow of a pathless hill, form, altogether, a scene for the last man. Further onward, in many parts, desolation prevails, and the appearance of the coast may be generally described as wild and sublime. Woodwick to Hermaness may be traversed without seeing a cottage or meeting a human being. Nature, in her weird garb, alone holds sway, the only signs of man being the brands on the sheep which roam about with the wild Shetland pony. These creatures, known by the name of "Shelties," though hardened by a tempestuous atmosphere, are the forewarners of an approaching storm; before it reaches them, they are seen slowly to follow one another to some sequestered hillside, and when "they are wet with the showers of the mountains, embrace the rock for want of a shelter." (Job xxiv. 8.) The names given to the points along this coast are merely for the use of the chart. Passing two small mountain lakes Tonga Point is reached. The cliffs along here, firmly based in the bed of the Atlantic, defy its stoutest sieges, though now and then yielding to it a mass of rock. Rabbits are found about here. A boundary railing is now passed; and nearly two miles further on, Hermaness, the most northerly point of Her Majesty's home dominions, is reached. This headland is surrounded by bold rocky cliffs, the haunts of many birds. Among these the eagle is said still to linger, and here that rare bird the "Brunxie," or Skua gull *(Cataractes Vulgaris)*, still builds its inaccessible nest. The only other British locality for this gull is on the lonely isle of Foula, eighteen miles off the west of Shetland, and on Rona Hill on the

Mainland. The Icelandic owl *(Strix nyctea)* has also been recorded here. The rocks of gneiss lying north of Hermaness are steep and naked, and on one called the Muckle Flugga, about a mile off the coast, the Unst lighthouse is erected. Its rock is ascended by an iron ladder, and the light 235 feet high is visible twenty-one miles off. A temporary lighthouse was here built in 1854, but so heavy a sea washed over it in the following winter as to endanger the building; so it was resolved to raise the lightroom fifty feet above the rock. The light is a fixed dioptic one, and was completed in 1858.

Following the western shore of Burra Fiord for about two miles, the residence of the lighthouse keepers is passed. Near here there is a small comfortable cottage, which may be regarded as the most northerly habitation of Great Britain. The opposite side of the Fiord is a high cliff of mica slate, displaying curvatures of strata, and it is pierced with many caves, one of which is reported to be large enough to admit a boat to the distance of two hundred feet. A trap dyke strikes along the cliff, passing by the head of the North Lake and its valley of limestone. Saxaford Hill is next reached; the view from its summit on a clear day embraces the whole Island of Unst. To the south lie barren hills of serpentine, without a bush to soften their sterility, and here and there the smoke issuing from the roof of some primitive cottage lying far below, reminds us of human habitations. The fleecy bands of cumuli variegate the azure of the sky, but in winter, how changed is the picture! Dark indigo takes the place of the bright cobalt of summer, and the Shetlander, confined to his thatched cottage, welcomes the smouldering peat in absence of the yule log. To the north stretches the dismal expanse of a boundless ocean, and the mind is filled with thoughts of the Boreal regions. A five-hour's sail to the east brings us in sight of Norway, and to the west Yell can be seen in the far-off horizon.

Saxaford is called after Saxe, a giant once supposed to inhabit the island, and Hermaness point likewise receives its name from his brother Herman. On the summit of the hill there are many loose stones, possibly the remains of an ancient watch tower. On the shore around this hill is the place where the alluvial gold is said to be found, and many water-worn pebbles of foreign rocks are seen. Sea birds abound on this shore, among which are the Lyre bird *(Procellaria Puffinus)*, the Tom Narry *(Alca arctica)*, and the Kittiwake *(Larus rissa)*. The eggs and feathers of these birds used formerly to be collected. Off Skaw Point, further eastward, there is a "roost," or opposition of tides, and about here the Cod and the Seethe, or Coal-fish *(Gadus carbonarus)* are taken. A cleft-like depression near Skaw is known as "Saxe's kettle." The open bay of Norwick is next reached. Here there are some cottages and the ruins of a kirk; the shattered remains of an arch are also to be seen. Crossing Niov Hill, more chapel ruins are passed, and the wide Haroldswick Bay (Harold's Bay) is reached, which, like Skaw and Norwick, offers no harbourage. Their bottoms are rocky, and they are deeper than Balta Sound. Haroldswick contains several cottages, some of the most primitive style, the fire

being lit on a flat stone in the middle of the floor, and the smoke escaping by no other chimney than a hole in the roof.

Heog's Hills and Crucifield are now again sighted, and, crossing them, I descended to Balta. Buness House, seen on the shore of the sound, is the handsome seat of the Edmonstones, and near it is a stone that marks the spot where the French philosopher, Biot, in the year 1817, carried on his experiments for determining in this latitude, the variation in the length of the seconds' pendulum.

And now, if you have had patience enough to follow these excursions, you will observe that the island has been traversed and Balta Sound once more arrived at.

The geographical terms of Unst are mostly Scandinavian. I subjoin a few to shew their meaning,—

-a, *-ie* } an island.—Balta, Uya, Hunie.
Brœ-, a low hill.—Brœwick.
Brough, ancient fortification.—Brough Pt.
Fiord, *Firth* } inlet.—Burra Fiord, etc.
Garth, an enclosure.—Hannigarth Vale.
Gruna, green.—Haaf Gruna.
Holm, an islet.—Woodwick Holms, etc.
Hou, high.—Houlon Ness.
Muckle, great.—Muckle Flugga.
Mull, peninsular.—Blue Mull.
Neap, perpendicular cliff.—Neap.
Ness, headland.—Hermaness, etc.
Ting, a place of meeting.—Tingwall on Mainland. Concentric circles.
Voe, an inlet of the sea.
Wart, a high spot.—Skaw Wart.
Wick, a small bay with a beach.—Wick, Sandwick, etc.*

MEETING, NOVEMBER 5TH, 1874.
The PRESIDENT in the Chair.

The fourth meeting for the term was held in the Physical Lecture Room. There were Thirty-six members and visitors present.

Dr. Tilden (hon. mem) proposed the following motion : "That it is desirable that a contribution be sent by this Society to the local fund, now being collected in anticipation of the meeting of the British Association in Bristol next summer." G. Dakyns seconded this motion which was carried unanimously. Dr. Tilden stated that he would be glad to receive subscriptions till the next meeting.

J. G. Grenfell, Esq. (Vice-President) then read a paper on "the History of Limestone," and exhibited two magnificent encrinites and other very fine fossils.

A vote of thanks to Mr. Grenfell closed the proceedings.

* Part of this paper was not read till the Michaelmas Term, 1875.

MEETING, November 19th, 1874.

The Vice-President in the Chair.

The fifth meeting of the term was held in the Chemical Lecture Room. There were Forty-two members and visitors present.

F. L. Cartwright then read a paper on "Petroleum," which he illustrated by numerous and effective experiments.

Dr. Tilden spoke upon this paper, and a vote of thanks to F. L. Cartwright terminated the meeting.

PETROLEUM.

Petroleum is the name given to mineral oils, which are found native in many countries. Many of these oils differ considerably in physical properties; some are thin and transparent, and have a pale colour, others are viscid, opaque, and nearly black; but these native oils all agree in possessing a strong bituminous smell, they are all inflammable and insoluble in water, and their specific gravity varies from 0·7 to 1·1. Petroleum is not a chemical compound but a mixture of a number of Hydro-Carbons, differing in density and volatility, and whose general formula may be given as $C_n H_{2(n+2)}$

When petroleum is submitted to distillation the first portions which distil over, at a temperature of about 100° C., are called naphtha. By law petroleum cannot be sold in the market till purified from these more volatile constituents. Rectified petroleum should not emit inflammable vapour before it is heated to 100° C. Vapour of petroleum explodes with fearful violence when ignited with oxygen gas. The least volatile portions of petroleum are called paraffin, a very useful substance, and which is now often procured by distilling petroleum.

The existence of petroleum has been known for a long time; the Greeks and the Romans used it as an illuminator, Herodotus mentions a spring in Zante; Bakoo, in Georgia, has been famous for its naphtha wells for centuries; Rangoon, in Burmah, possesses 500 wells, sixty feet deep, and which produce over 400,000 hogsheads of naphtha annually; but in the last few years the petroleum wells of Pennsylvania have surpassed all these, both in the quality and the amount they produce. Twenty years ago petroleum was almost unknown in America, now it has become its most important article of exportation, next to cotton.

At Amrano, in Italy, petroleum has been extracted for the last 200 years, by merely digging pits in the ground and collecting the liquid that oozed from the soil, in vessels at the bottoms of the pits. No attempt had been made to purify the oil, and it was used in a crude state, as a means of lighting the cities of Parma and Genoa. In 1817 de Saussure published an account of this petroleum, which he had examined. He described it as being a transparent, yellow, thin liquid; specific gravity ·836, with a strong persistent smell; separable, by distillation, into a colourless, lighter and more volatile portion, and a heavier, less volatile portion. The lighter portion he called rectified naphtha.

Petroleum generally occurs in depressions of the strata, and is brought to the surface by means of artificial wells, which, in America, costs about £1200 a well. When the oil is reached it generally rushes up with great force, and in vast quantities, sometimes as much as 1000 barrels a day being ejected; but the quantity very soon diminishes, and the miners have to resort to pumps. Besides the artificial wells there are such things as intermittent wells, which only produce oil two or three times a day, but when the oil is ejected it very often rises to a height of fifty feet.

All petroleum contains a greater or less amount of bitumen or asphaltum, and also a certain amount of paraffin. This paraffin is separated from petroleum by cooling mixtures and pressure. The average yield is about one pound of paraffin for four gallons of petroleum. The paraffin is used for lubricating and for candles. The more bitumen there is in petroleum, the more like tar does it become; and if the amount be very great, the petroleum passes into a substance which possesses so little fluidity as to be solid at ordinary temperatures. In this condition it is found in Tar Lake, in the Island of Trinidad, and is then used for making pavements.

The want of a suitable vessel for the transportation of petroleum has long been felt. Near the Burmese springs vessels peculiarly suitable for the exportation of petroleum are manufactured. Ordinary barrels, although tight enough to prevent other liquids from passing through them, do not prevent the leakage of petroleum. It is said that ten per cent. of petroleum is lost on the journey from the wells in Pennsylvania to New York. When petroleum was first exported from America to Europe in ordinary casks, the casks were found empty on arriving. At present barrels lined with zinc are used to transport petroleum beyond sea.

The uses of petroleum are various. When rectified it is used as an illuminator, and it gives a much brighter light than either oil or paraffin candles, and besides, it has this advantage over oil, that it does not dirty lamps like olive oil. It has also been proposed to use petroleum as a producer of motive force, and a machine has been constructed in which petroleum is used as fuel. The thicker kinds of petroleum are used for lubricating machinery. Petroleum is also used for dissolving grease. The paraffin and bitumen contained in petroleum are also made use of as already mentioned.

Of the origin of petroleum very little is known, but the similarity existing between petroleum and the compounds produced by the destructive distillation of coal, renders it probable that petroleum has been formed by the destructive distillation of animal and vegetable matter. The general opinion as to the origin of petroleum is, that it has been produced by the action of heat on coal beds. But to this theory there are several objections; thus, for instance, anthracite, which would be the most likely of all kinds of coal to be the residue of a process of destructive distillation, as it contains the smallest amount of volatile substances, does not shew any indications of having been exposed to a temperature high enough to volatilise petroleum.

Petroleum has also been found in silurian rocks, which existed long before our coal-fields were produced. Reichenbach made a theory on the origin of petroleum, which has since been proved to be erroneous. The petroleum he examined contained no paraffin, and at the time he made his experiments (1833) no petroleum had been found in coal-beds which had been exposed to a high temperature. He also obtained an oily liquid, resembling petroleum in appearance, by distilling coal with water, but which smelt of turpentine oil. He concluded from these facts that petroleum was not a product of the distillation of coal, but a constituent of it, and that it was probably the turpentine oil of primeval forests.

MEETING, December 3rd, 1874.

The President in the Chair.

The sixth meeting of the term was held in the Physical Lecture Room. There were Twenty-nine members and visitors present.

M. Heard then read a paper upon "the Cairngorm mountains." At the conclusion of the paper the President complimented the writer upon the excellent English in which the paper was written, and on the love of natural scenery which he had displayed. The President also made some remarks upon the points of interest touched upon in the paper.

A vote of thanks to M. Heard terminated the meeting

MEETING, December 18th, 1874.

The President in the Chair.

The seventh meeting of the term was held in the Physical Lecture Room. There were Seventeen members and visitors present.

H. P. Burt read a long and interesting paper upon "Polar Exploration." At the conclusion of the paper G. H. Wollaston, Esq., President, spoke at considerable length upon the subject of the paper.

The meeting, the last for the year 1874, closed with an unanimous vote of thanks to H. P. Burt.

LENT TERM, 1875.

MEETING, February 4th, 1875.

The President in the Chair.

The first meeting of the term was held in the Physical Lecture Room. There were Forty-five members and visitors present.

After some introductory remarks by the President, J. E. Pearson, Esq. (O.C. and hon. mem.), read a paper upon the Transit of Venus.

At the conclusion of the paper, after a few remarks from the President, a vote of thanks was proposed by the President, seconded by the Vice-President, J. G. Grenfell, Esq., and carried unanimously.

The President then announced that the meeting would proceed to the election of officers for the current term, and stated that as all the retiring Committee, consisting of Messrs. Dakyns, Moser, Heard, Cartwright, offered themselves for re-election, he should, to save time and trouble, propose the retiring Committee for re-election in a body, unless any member objected. As no objection was raised the President proposed this motion, which was seconded by the Vice-President, and carried unanimously.

The meeting then adjourned.

ABSTRACT OF PAPER ON THE TRANSIT OF VENUS.

When we are in a moving train the objects around seem moving in the opposite direction to us, the nearer objects more quickly, the further more slowly. This is because we have to turn our heads round to keep them in sight, just as we should if they were moving and we at rest; and we do not turn our heads so quickly for the more remote as for the nearer objects. We can roughly estimate the distance at which an object is by seeing how far we turn our head, or to speak more strictly, if we are given two places and know the direction in which we have to look for each to see the object. This is the way in which maps are constructed, and it is in fact by the same method that we always judge distances; the lines from an object to our eyes are never quite parallel, and if the object is very near our eyes we squint, and the further it is the less we squint, and by the amount of squinting the mind judges the distance.

The further the object is in proportion to the distance between the places of observation, the less accurate the method becomes, and it quite failed in the fixed stars, so it was proposed to take observations at intervals of six months, so as to have as base the diameter of the earth's orbit—a distance of more than 180 millions of miles. The distances of some of the nearest fixed stars are as follows, and contain 210,000 times the radius of the earth's orbit: Sirius, 1,375,000; Polaris, 1,946,000. Light from Polaris would take thirty years reaching us.

The distance of the sun is too great to be measured by the first method, as will be readily seen from the following representation of the solar system by Herschel,—"On a level field place a globe, two feet in diameter, to represent the sun; Mercury will be represented by a grain of mustard seed, on the circumference of a circle 154 feet in diameter for its orbit; Venus, a pea, on a circle 284 feet in diameter; the Earth also a pea, on a circle 430 feet in diameter; Mars, a rather large pin's head, diameter of orbit 650 feet; Jupiter, a moderate sized orange, half a mile; Saturn, a small orange, four-fifths of a mile; Uranus, a large cherry, a mile and a half; Neptune, a large plum, two miles and a half."

The paper then proceeded to describe the methods of observation and calculation, and explained the difficulties of exact observation on account of "the black drop." If we heat a platinum wire to a white heat it appears as thick as coarse string, and, in a similar way, the light of the sun makes Venus, in crossing, seem too small until she reaches the edge, when the light on that side is cut off, and she seems to put out a small black claw to the edge of the sun's disc—just in the same way as if we look at a window with a half-shut eye, we see a fringe of light surrounding it, and if we pass a finger between our eye and the window we shall find it difficult to mark the exact time when it crosses the frame, because the fringe surrounding the frame is cut into by the fringe surrounding the finger.

MEETING, February 28th, 1875.

The President in the Chair.

The second meeting of the term was held in the Physical Lecture Room. Owing to the inclemency of the weather there were only Eighteen members present.

The Secretary, G. Dakyns, was then moved to the chair, and G. H. Wollaston, M.A., proceeded to read a paper upon "Platina."

The paper was illustrated by several curious and interesting specimens, which belonged to the late W. H. Wollaston, M.D.

The meeting was closed by an unanimous vote of thanks to Mr. Wollaston.

MEETING, March 11th, 1875.

The President in the Chair.

The last meeting for the term was held in the Physical Lecture Room. There were Sixty-two members and visitors present.

G. Dakyns, the Secretary of the Society, was moved to the chair. The President then read a paper on "Volcanoes."

An unanimous vote of thanks to Mr. Wollaston closed the proceeding.

SECOND TERM, 1875.

MEETING, May 13th, 1875.

The President in the Chair.

The first meeting of the second term of the year 1875 was held in Physical Lecture Room. There were Twenty-three members present.

The first business of the evening was to elect a Treasurer of the Society, vice H. Moser (left). F. L. Cartwright was elected unanimously.

For the five members of the Committee,

H. P. Burt	was proposed	by	M. O. Norris	seconded by J. Teague.
M. Heard	„	H. Maw	„	W. H. Ley.
G. Dakyns	„	G. H. Wollaston, Esq.	„	H. Burt.
Dr. Tilden	„	G. H. Wollaston, Esq.	„	M. O. Norris.
H. C. Jones	„	H. P. Burt	„	M. O. Norris.

As there was no other candidate these gentlemen were proposed by the meeting in a lump, and elected *nem. con.*

The President then exhibited a great quantity of fossils and other objects of interest, a number of which had been presented to the Society by Joshua Saunders, Esq.

The President announced that the Museum would be opened on the occasion of the Guthrie Commemoration.

MEETING, May 20th, 1875.

The President in the Chair.

The second meeting of the term was held in the Physical Lecture Room. There were Twenty-seven members and visitors present.

J. G. Grenfell, Esq., Vice-President of the Society, read a long interesting paper upon "Starfish." The paper was illustrated with numerous diagrams and some splendid specimens. At its conclusion some remarks were made and some questions asked by the President and Dr. Tilden. The Vice-President replied shortly. The President then thanked Mr. Grenfell for his great kindness in reading this paper, of which he had only a week's notice.

The President then announced a further donation of minerals from William Sanders, Esq., F.R.S., and a vote of thanks to Mr. Sanders was carried unanimously, and the Secretary was directed to notify the same to Mr. Sanders.

MEETING, June 3rd, 1875.

The President in the Chair.

The third meeting of the term was held in Mr. Wollaston's Den. There were Eighteen members and visitors present.

Dr. Tilden being moved to the chair the President of the Society, G. H. Wollaston, M.A., read a paper on "Certain Trees," confining his remarks almost exclusively to the "oak," which subject was treated in a manner that interested all present.

Upon the conclusion of the paper Dr. Tilden asked several questions which were answered by the President.

A vote of thanks was proposed to Mr. Wollaston by M. Heard, and seconded by H. C. Jones.

The meeting then adjourned.

MEETING, JUNE 24TH, 1875.

The PRESIDENT in the Chair.

The fourth meeting of the term was held in the Chemical Lecture Room. There were about Thirty-five members and visitors present.

H. C. Jones read a paper upon "Coal Gas," which he illustrated with several very effective experiments. At the conclusion of this paper, some conversation took place on its subject, in which the President, Dr. Tilden and Jones joined.

COAL GAS.

Perhaps it may be advisable to spend a few minutes in tracing the history of the discovery of this gas which now plays such an important part in every day life, and without the use of which we should suffer great inconvenience. The existence and inflammability of coal gas has been known for nearly 200 years, but its properties were made of no practical use till within quite recent times.

In 1659, the combustible gases, which supplied the burning mill of Wigan, were attributed to the beds of coal which lie under that part of the country. From this curious phenomenon a Dr. Clayton was induced to experiment on coal. He found, when it was roasted in a closed vessel, that the products were water, black oil, and a spirit, as he called it, which was incondensible: the latter, of course, is unpurified coal gas. This was a hint, which, in an age more alive to economic improvement, might have brought gas-lighting into use a century sooner. Another fact which brought this gas again before the public was, that in 1733, Sir James Lowther noticed a spontaneous evolution of gas at his colliery,—his men were one day surprised by a sudden rush of air, which took fire on coming in contact with a candle, burning with a flame two yards high, and one in diameter; they were much frightened, but had the presence of mind to put out the conflagration. The steward, on hearing of it, went down himself, and again lit it; the rush of gas had however increased, and consequently he found more difficulty in extinguishing it. Of course it annoyed the workmen, and a large tube had to be carried up the shaft to take the noxious gas out of the pit, and at the top it was lit, and burnt for two years and nine months, without showing signs of decreasing. It became the custom of the neighbours to fill large bladders with it, to which were attached small pipes, so that they might use it at their own convenience. This is the first instance of the gases obtained by heating coal being used either for lighting or heating purposes. But though the properties of this gas were known, nobody thought of applying it systematically to the use that is now made of it, till 1792, when an engineer, in Cornwall, erected a small gasometer and apparatus for supplying his offices and house. So pleased was he with the result, that, in the following year, he undertook to supply a manufactory at Soho with gas. This was the first application, in a large way, to lighting purposes, but, except among manufactories and scientific men, it excited little attention till 1802, when the above

manufactory was brilliantly illuminated on the occasions of the public rejoicings at the Peace. Such a striking difference was there between the dingy lamp and the new light, that it began to make real progress in the large commercial towns. London seems to have been the town most unwilling to avail itself of the new invention, and the cause, no doubt, was that no means of purifying it was known, and consequently it was dirty, caused headaches, and spoilt delicate furniture. This was of little consequence in a manufactory, where there is generally sufficient ventilation to carry off unpleasant vapours, and rarely very delicate organs or fine furniture to suffer from it. But by degrees it crept into use in the metropolis, and, whereas in 1807 Pall Mall alone had the benefit of being lighted, now, without exception, every alley in London is, and no less than eight millions and a half of cubic feet are consumed daily.

Foreign nations are by degrees adopting its use, and the most important towns on the continent have been or are being supplied with this gas. Such is the brief history of an invention which will never cease to be of use, and which may be applied to many more employments than it is at present.

I will now turn my attention to the manufacture and products of the distillation of coal.

The manufacture of coal gas is a branch of industry of great interest and importance in several points of view. The process is one of great simplicity of principle, but requires in practice some delicacy in management to yield a good result. The products of the distillation vary in their proportions with the temperature at which the process is conducted, the permanent gases becoming more abundant with increased heat, but at the same time losing much of their value for the purposes of illumination. It would be a waste of time to describe in detail the manufacture of this gas, which is more or less known to us all, but I intend to give my attention more especially to the composition of the gas, and the uses of the bye-products.

The best coal for this purpose is that which is highly bitumenized, as that which is commonly called cannel-coal.

The gas after leaving the retorts is purified, and contains, after this operation, methane (CH_4), ethylene (C_2H_4), ethene (C_2H_2), H, CO, N, and vapours of volatile liquid hydro-carbons, besides vapour of CS_2. Marsh gas (CH_4) is found abundantly in coal mines, and is frequently disengaged from what are technically called "blowers," which are holes in which the gas has been pent up, where probably it has been formed by the action of the heat on the coal. It can be artificially prepared by heating Na $C_2H_3O_2$ with Na HO. The gas we burn contains from 51 to 41 per cent. of this gas, and consequently it is by no means an unimportant constituent. The colour of its flame is yellow, but it is not to this constituent that the gas owes its luminosity.

Olefiant gas (C_2H_4) is the most important compound of the coal gas, though 100 volumes of the latter only contain from 22·6 volumes of olefiant gas. The luminosity of this gas is far superior to that of marsh gas. It can be prepared by heating alcohol (C_2H_6O) with H_2SO_4:

acetylene (C_2H_2) is present in small quantities. If the ordinary gas we are in the habit of burning is passed through cupreous oxide, the characteristic red precipitate ($C_2H\ Cu_2)_2O$ is formed, and indeed in this way it may be prepared pure by the addition of H Cl.

Hydrogen is rather detrimental than otherwise to the luminosity, but for heating purposes of great use. In 100 volumes of coal gas between 34 and 13 are H. CO is present, but it is not easily separated from the other gases, and, as there is only about 7 per cent. of it, it is of no great harm, though poisonous if present in much larger proportions.

The gas is usually contaminated with N and O, the presence of which may be accounted for by knowing that the pipe joints are not perfectly tight, and therefore diffusion takes place.

The luminosity of the gas is in some degree, as well as its smell, due to the vapours of volatile hydro-carbons. In a very hard frost gas seems to loose some of its lighting powers: the fact is that these hydro-carbons are condensed in the pipes, but again volatilize on the temperature rising. There are generally traces of carbon di-sulphide, the most noxious of its constituents, but the quantity is very small indeed. If, however, gas be drawn through a tube in which a red hot coil of copper is placed, after several hours it will be found to have been coated with a black deposit, which is copper sulphide. The cracking of the bindings of books, and tarnishing of the gilding on pictures is due to this, and the reason silver becomes discoloured so quickly in the great towns is from the presence of CS_2 and SO_2. These are the most important constituents of the gas we burn, and I will now pass on to the bodies previously separated in the condensers and purifiers.

Tar and volatile oils form a large portion of the product of the destructive distillation of coal; these bodies for the most part having a high boiling point, condense in the hydraulic main, together with water containing the NH_3 in solution, the more volatile compounds being condensed in the refrigerators. The liquid is treated with weak hydro-chloric acid, by which the alkali is neutralised, and the liquid is separated by mechanical means, as far as possible, from the tar.

The solution containing ammonium chloride, and impurities is evaporated to dryness in iron cauldrons, and carefully heated to expel or decompose the tarry matter, it is then purified by sublimation, in large iron vessels lined with clay, and surmounted by domes of lead. The crystals thus obtained have a fibrous texture, and are tough and consequently difficult to powder. This salt occurs native in many volcanic districts, also in small quantities in sea water; but our supply, before it was obtained from ammoniacal liquor, was from Egypt, where it is prepared by sublimation from the soot of camels' dung.

This salt is of great use in the laboratory, for from it NH_3 is easily prepared, also for freezing mixtures. It is employed in dyeing, and in metal works as a deoxidising agent, especially for copper. It enters into the composition of a cement used for fixing iron into stone: this is formed by moistening, with a solution of sal ammoniac, iron filings

mixed with 1 or 2 per cent. of sulphur. Impure sal ammoniac is now largely used as a manure. Coal tar itself is of little use, but it contains some most important constituents, such as benzene, phenol, and picric acid. The crude liquid is subjected to repeated distillations, the more volatile and light hydro-carbons together with alcohols and ethers pass over first. After the distillation has continued some time, a residue is left, consisting of pitch or asphalt, also solid hydro-carbons, together with resinous compounds. It would be waste of time to describe the numerous uses these bodies are put to, as they are so numerous and manifest. The distillate, therefore, from the crude tar will engage our attention now.

The more volatile portion consists of "light oil," or naphtha, composed mainly of benzene and its homologues, while "dead oil," or the less volatile part contains phenol and cresol, also aniline, picoline, and a number of solid hydro-carbons, including naphthaline, and anthracine. All the above-named substances are valuable for some reason, especially benzene. This interesting and extremely valuable product of coal boils at 82° C., and therefore passes over with the first portion of the distillate It is prepared pure by repeatedly washing with H_2SO_4 and Na HO, the coal-tar oil, to remove acids and alkaline products likewise existing in it; the neutral oil thus obtained is submitted to repeated fractional distillations. It is now prepared in immense quantities for the manufacture of aniline, which plays such an important part in our dye works. Benzene is a thin, limpid, colourless liquid, having a power of dissolving iodine, sulphur, phosphorous, and resins, hence it is used in many chemical preparations and for removing grease spots from articles of dress.

By acting on benzene with the strongest nitric acid, nitro-benzene is formed; this substance has a peculiar almond-like smell and taste, and is extensively used for scenting soaps. It was used as a flavouring agent, but so many accidents arose from its poisonous character, that this practice has been discontinued. From benzene is made the highly interesting substance, aniline, which finds an extensive application in the arts, a long series of colours unequalled in brilliancy and beauty having, by the action of different oxidising agents, been produced from it. I think it will not be out of place to look shortly into the modes of preparing a few of the most important. Aniline-purple, or mauve, is obtained by mixing a solution of aniline sulphate and potassium bichromate, and allowing the mixture to stand for several hours; the black precipitate is filtered off and purified from admixing potassium sulphate by washing with water. It is then dried, and freed from resinous matter by repeated digestion with coal-tar naphtha, and finally dissolved in alcohol. It is then usually purified further by evaporating to dryness, and dissolving the residue in boiling water, re-precipitating with soda, and dissolving in alcohol again.

Mauve thus prepared forms a brittle substance, having a bronze-coloured surface; it is with difficulty soluble in cold water, though it imparts a deep purple colour to it.

Aniline red, or rosaniline, next engages our attention. The most advantageous mode of preparation is the following:—A mixture of twelve parts of dry arsenic acid ($As_2 O_5$) and 10 parts of aniline, is heated to about 120° C with water for several hours. The product is a hard mass possessing the lustre of bronze. To separate it from any unchanged aniline it is boiled with sodium hydrate, and filtered; and to the precipitate, weak acid is added, which dissolves rosaniline, leaving the tarry matter. The compounds of this salt, with one atom of acid, furnish a very intensely coloured red solution in water. Hoffman has shown that pure aniline is incapable of furnishing aniline red, and that toluidine and aniline must be present.

Aniline blue is obtained by digesting rosaniline with an excess of aniline; it is purified much in the same way as the two preceding colours. The most important of these colours are those known as aldehyde green and iodide green. The former is produced by adding 1½ parts of aldehyde to a cold solution of magenta. The mixture is then heated in a water bath, and finally poured into a solution of sodium thiosulphate. The liquid is now boiled and filtered. The filtrate contains the green, which may be precipitated by tannin or sodium acetate. The colour is principally used in silk dye works.

Iodine green is made by heating the violets of triethyl or trimethyl rosaniline with iodide of methyl, ethyl, or amyl. It is much used for cotton and silk dyeing.

Besides benzene, from which aniline, and, consequently, its colour is prepared, the tar contains toluene, metad par-anilene, anthracene, pyrene, phenol, and cresol, together with many other hydro-carbons of less importance.

It will not be necessary to describe the properties of all these, but such as phenol and picric acid, and a few others, deserve our attention; time being limited, we must confine ourselves to a very limited number.

Phenol ($C_6 H_6 O$) goes by the names in commerce of "carbolic acid" or "coal tar creosote;" it is contained in considerable quantities in coal tar. Commercial creosote often consists almost entirely of phenol, but the true creosote, obtained by the distillation of wood, is a totally different substance. The mode of preparation from the tar is both complicated and tedious, possessing little that is of interest. It can be obtained in small quantities by placing commercial carbolic acid with calcium chloride for some days in a freezing mixture; in this reaction the cresol, also present, is probably converted into phenol by the chloride of calcium. This substance crystallizes at the ordinary temperature in long colourless needles. It is used for preserving from decomposition animal matter, removing the fœtid odour from meat and other substances already in a decomposing state. It is due to the presence of this in no small degree that the tar has such a power of preserving organic matters. Hop sticks, nets, and other

things much exposed to the action of water, are often preserved by dipping them into hot phenol, certainly in a very impure state, but possessing, nevertheless, its properties.

From this is prepared picric acid, which is of importance, so a few moments will be devoted to its description.

Picric acid ($C_6 H_3 N_3 O_7$) is usually made by treating crystallized phenol with nitric acid, but this is not the only way; various other modes of preparation being known. It crystallizes in light yellow shining laminæ, having an intensely bitter taste, and is or was used in the place of hops in beer. This acid is extensively used for dyeing silk and wool, especially the former. The bright yellow colour resists the action of light, but is affected by washing, particularly with soap. Picric acid forms many compounds of interest. I have here the picrate of potassium ($C_6 H_2 K (N O_2)_3) O$, which is made by adding hot solutions of potassium chloride and picric acid to one another; on cooling, the liquid deposits fine prisms. I have left unnoticed both the coke remaining in the retort and that peculiar modification of carbon which is used in the voltaic cell; both may be consumed, the latter requiring especially a fire with good draught.

It was only a few years ago that the compound called aniline was made of any practical use; and this may serve as an example to show how extremely likely it is there are still substances obtained by the destructive distillation of coal, which may in future years be turned to the greatest use. I must apologise for not having mentioned many of the valuable and useful products obtained, but I have trespassed already too long on your time, and must leave them to be discussed on another occasion.

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